SIMPLEServo®

Indexing Digital Servo Drive Programmer's Manual

Applied to Models:

SSi1004 SSi1004-3P
SSi1008 SSi1008-3P
SSi1010 SSi1010-3P
SSi1012-3P

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1. Getting Started

1.1 Introduction

Definitions

The SimpleServo Indexer (SSI) is a digital motion controller that will process commands within the hardware and software limits dictated by user (wiring, configuration, parameters, program statements, events, etc.). The output of the system is the motion(s) created in response to the command(s) input.

The SimpleServo SimpleMotion programming language (SML) provides a very flexible development environment for creating solution to motion application. As opposed to indexers with simple command interpreting mode, language based indexer allows you to create complex and intelligent motion, flexible processing of inputs, complex logic decision making and program branching, timed events processing and number of functions mostly found in PLC controllers.

The MotionView is a universal setup and configuration program used for all SimpleServo products. It has self-configuration mechanism that adapts it to particular product automatically.

The MotionView Studio tools suite contains all the software tools needed to program and debug a SimpleServo Indexer. MotionView Studio is a part of MotionView program. It constrains a full-screen text editor, program compiler, status and monitor information and debugger (the tool allows you to step through program you are developing).

The User Program (or Indexer Program) is user-developed program describing programmatic behavior of the SSi. User Program can be stored in the text file on your PC or in SSi's memory. User Program needs to be compiled (translated) in binary form before SSi can execute it with aid of MotionView Studio tools.

Safety Warnings

Warning!

• Hazard of unexpected motor starting! When using the MotionView software, or otherwise operating the SSi drive over RS-232/485 or Ethernet, the motor may start unexpectedly, which may result in damage to equipment and/or injury to personnel. Make sure the equipment is free to operate in this manner, and that all guards and covers are in place to protect personnel.

Warning!

• Hazard of electrical shock! Circuit potentials are at 115 VAC or 230 VAC above earth ground. Avoid direct contact with the printed circuit board or with circuit elements to prevent the risk of serious injury or fatality. Disconnect incoming power and wait 60 seconds before servicing drive. Capacitors retain charge after power is removed.

Getting started with SSi

Before SSi can execute motion program it has to be properly installed and configured. First time users are encouraged to read through the appropriate sections in this manual and in SimpleServo User's Manual for proper hardware installation and configuration.SSi programmable features and parameters

SSi drives have a number of features and parameters which can be programmed via MotionView Software. Below is a list of programmable features and parameters specific for SSi drives in order they appear in left tree of the MotionView. Please refer to User's Manual for details on these parameters.

Motor folder

This folder contains action button to choose particular motor. The rest of the fields contain information about selected motor. See MotionView Help on detailed information how to setup motor.

Parameters

- **Drive mode**
  PIVFF mode. **P**(roportional) **I**(ntgral) **V**(elocity **F**(eed**) F**(orward) regulator configuration. This mode using tunable position loop. Velocity feedback is used as dumping term and adjusted automatically. Velocity feed forward gain is adjustable.
- **P+V** mode. P(osition) +V(elocity) regulator configuration. This mode is generally slower than PIVFF and used with lower performance mechanics. Regulator consists of outer position loop followed by independent velocity loop followed by current loop. Position and velocity loop gains are in tacked in this mode.
- **Current Limit**
  Sets RMS motor current limit. Settings per phase Amps RMS
- **Peak Current Limit**
  Sets RMS per phase peak current limit. This current limit is allowed for 2 Seconds. After that it will be folded back to the level that is set by Current limit parameter.
- **Autoboot**
  If this option is selected after Power Up SSi will start execution of the user program. Otherwise the program must be started manually via MotionView software or via Host Interface.

Warning!

• Hazard of unexpected motor starting! When using the MotionView software, or otherwise operating the SSi drive over RS-232/485 or Ethernet, the motor may start unexpectedly, which may result in damage to equipment and/or injury to personnel. Make sure the equipment is free to operate in this manner, and that all guards and covers are in place to protect personnel.

- **Feedback loss detection**
  When this option is enabled SSI will detect feedback loss, then consequently disable, and generate fault.
- **RS485 configuration**
  Switches between different protocols can be used over RS485 interface. In normal mode, PPP protocol (described in Host Interface manual) is used. "Modbus slave" is another alternative protocol can be used to communicate with SSI drive. Modbus primarily supported for compatibility with industry standard operator interfaces and terminals. For all other control tasks, PPP is recommended.

- **Group ID**
  This parameter is used to combine different SSIs in functional groups. SSIs with the same group ID can be communicated simultaneously with statement SENDTO. See statements SEND and SENDTO for farther explanations.
- **IP Properties**
  Displays properties and settings for Ethernet communication port.

I/O

- Output 0 (1,2,3) function
  Every digital output except output #4 can be assigned special function
  Refer to Section 1.6 to see list of available functions.
- Hard limit switches action.
  Inputs A0 and A1 serve as Hard Limit switches inputs. If <No Action> option is selected then inputs have no effect on SSi operation as can be used as general-purpose inputs. Refer to Section 1.6 for detail on each action item.

Limits

Position Limits

- **Position error**
  This parameter sets maximum allowable position error before "Position Excess Error" fault will be generated. This parameter works in conjunction with "Max Error Time". Position Error is set in primary motor encoder quadrature counts.
- **Position error time**
  This parameter sets time how long position error allowed to be bigger then limit set by "Position error" parameter until "Position Excess Error" fault will be generated.

Compensation

Velocity Loop filter

These parameters have an effect on velocity regulator behavior when SSi placed in V+P mode. It has no effect in PIVFF mode

- **P-gain** Velocity loop Proportional gain
- **I-gain** Velocity loop Integral gain

Refer to Section 1.10 for details on SSi position and velocity regulators behavior in both P+V and PIVFF mode.

Position Loop filter

This parameters have an effect on position loop regulator and

- **P-gain** Position loop Proportional gain
- **I-gain** Position loop Integral gain
- **D-gain** Position loop Derivative gain
- **VFF-gain** Position loop velocity feed forward gain
- **I-limit** Position loop Integral gain influence limit

Refer to Section 1.10 for details on SSi position and velocity regulators and regulation diagrams.

Indexer Program
This will select the MotionView Studio section of the MotionView. Right panel is used to enter edit and debug User Programs. Menu and toolbar will display additional features needed for program preparation compiling debugging and loading to the SSi's memory. Motion View Studio tools and operations are described in details in Section 1.3

Security

This option will protect source code of the User Program with password. If password was set then SSi will ask for password before displaying User Program text. Password can be any alphanumeric string.

1.2 Programming flow overview

Welcome to SimpleServo SimpleMotion programming language (SML) - the quick and easy way to create powerful motion application. With SML you describe your system logistics, motion, I/O processing and user interaction programmatically i.e. creating program. The program consists from list of statements with optional parameter(s). There are different statements for motion, processing I/O, events, program flow control, and full set of arithmetic and logical operators. For more detail, refer to "Language Specification" Appendix A on the back of this manual.

In order for SSI to understand statements, they need to be compiled (translated) to the binary machine code. This happens when you done writing program and hit toolbar button "compile" in the MotionView Studio environment. After compilation (translation), the binary machine codes and program text (source code) are both loaded into the SSI memory and stored in the internal SSI's flash memory. Fig. 2.1 below summarizes program preparation process.

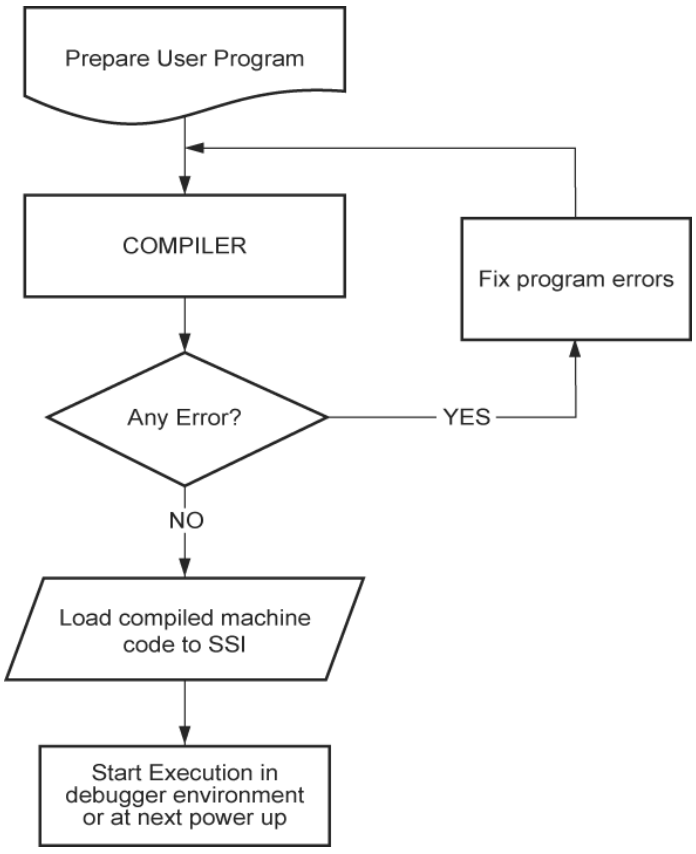
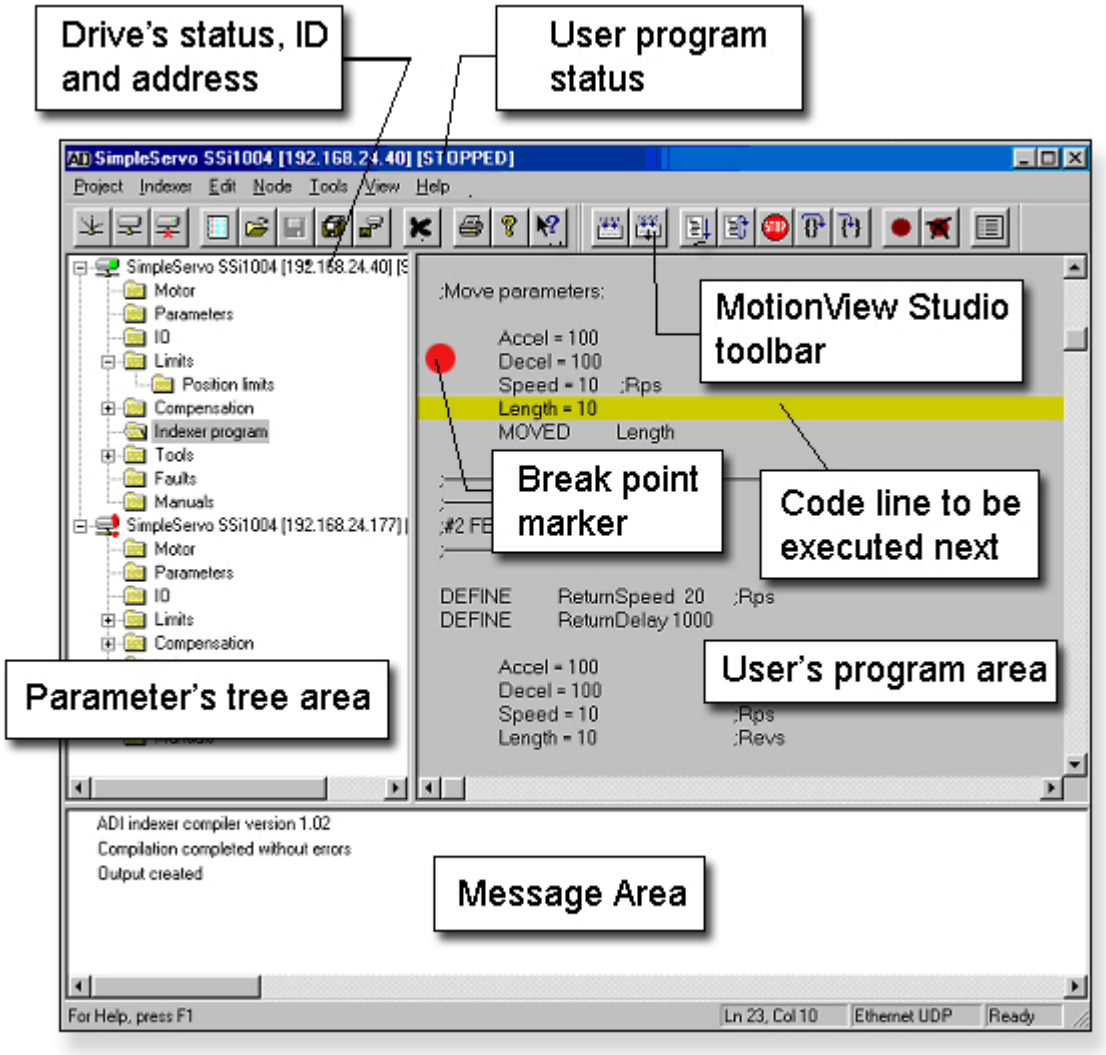


Fig. 2.1 Indexer program preparation flowchart

1.3 MotionView Studio



MotionView Studio screen layout

MotionView Studio is a powerful tool suite used to enter, compile, load and debug User Programs. MotionView studio is part of the MotionView universal program. MotionView Studio becomes available when user selects "Indexer Program" folder from MotionView's parameter tree. Motion View Studio consists of three parts: Editor, Compiler and Debugger.

When Motion View starts, it always loads current program text from SSi's memory to the editor window. This action is always performed regardless program run state.

MotionView Studio toolbar Icons From Left to Right:

Compile, Compile and load, Run, Reset Program, Stop and Disable, Single Step (Step Over), Single Step (Step Into), Set Breakpoint, Remove breakpoint, Display Watch Window.

To load User program from PC use <Edit> <Import program from file> menu. Executing this menu loads program from file to editor window. It doesn't load it to SSi memory yet.

To compile program and load it to SSi's memory use <Indexer> <Compile and load> menu. You can use <Indexer> <Compile> menu to compile and check syntax errors without loading program to the SSi' memory. If the compiler finds any syntax error, compilation stops and program will not be loaded to drive's memory. Errors are reported in bottom portion of the screen in message area.

To save program on PC disk use <Edit> <Export program to file >.

To execute program use <Indexer> <Run> menu.

To execute program step by step use <Indexer> <Step Over> menu. SSi will execute program one step at the time. Current program statement will be highlighted.

Breakpoint(s). It is convenient to set point in the program where you would like to stop and evaluate some results. You can do it by pointing to lines of code you would like program to stop and hit <Indexer><Set Breakpoint>. Red dot will mark the line showing that program will be stopped if it reaches this line before executing it. Executing stop doesn't disable drive and all position variables are valid.

To Stop program execution and disable drive use <Indexer><Stop>. Program will stop after completing current statement. You can resume program by hitting <Indexer><Run>.

To Reset Program execution from the beginning use <Indexer><Reset>. Program will be reset and drive will be disabled. All position variables will no longer be valid.

1.4 Programming Basics

It is usually useful to have all the moves a machine will do, along with I/O statements, etc., in a program. We will now explore how programs are written and used.

Make sure the indexing drive is connected to your computer and on-line.

Select <Indexer program> on the left tree. MotionView loads program from indexer memory automatically to the right window. Note that if there is no valid program in the indexer memory window on the right will be empty. Clear program text on in the right window if any appears then type in following program:

```
UNITS=1
ACCEL = 5
DECEL = 5
ENABLE
MOVED 10
MOVEDISTANCE  -10
END
```

After the text has been entered, select <Compile and load> from <Indexer> menu. After compilation is done, message box will be displayed suggesting that our program has errors. Click <OK> to dismiss dialog. The message window (bottom portion of your screen) will display Compiler error(s). Program line with an error is highlighted. The line "MOVEDISTANCE -10" generated syntax error because "MOVEDISTANCE" not a valid command. Change text "MOVEDISTANCE" to "MOVED" :

```
UNITS=1
ACCEL = 5
DECEL = 5
ENABLE
MOVED 10
MOVED -10
END
```

Select <Compile and load> again from <Indexer> menu. There should no longer be any errors. Since program was successfully compiled, it gets loaded to the drive memory and ready to run. Run the program by selecting <RUN> from <Indexer> menu. After program finishes, drive stays enabled. Click <Indexer->Restart> to disable the drive and reset program execution from the start. Note that program doesn't run itself automatically. You have to select <Indexer->Run> to run it again.

After you are done with writing the program and drive setup you can save them by using <Node|Save configuration As.>. Indexer program is a part of drive configuration and also saved in the same file. There will be a time when you need to import (or export) program source to the other drive or perhaps you prepared program off-line and what to load it to drive later. You can use Indexer|Load from text file> menu to load program source to the drive. You also can open new configuration file by selecting <Node| New configuration file>, go to "Indexer program" folder on the left tree, and type your program in the right pane, then save configuration file to the disk and later load it to the drive memory by selecting <Node|Load configuration file to drive> menu. Remember that when you do so, drive configuration parameters will also be loaded. If you want to preserve drive configuration and load a program only, use file-importing method described above.

Units

All motion statements in the drive work with User units. Statement on first line of the test program UNITS=1, sets the relationship between User units and motor revolutions. It simply answers the question: "How many User units in one motor shaft revolution?" If this statement is omitted from the program, the motor will operate with encoder counts as User units.

Time base

Time base always in seconds i.e. all time-related values are set in USER UNITS/SEC.

Enable/Disable

After execution of the statement ENABLE, drive will be enabled. If drive was disabled before execution of that statement then the absolute position counter will be reset to zero.

Execution of the statement DISABLE will disable the drive and clear motion stack.

Attempt to produce motion when drive is disabled will generate fault.

Faults

When fault condition has been detected by the drive, the following events occur:

If a program is executing it is stopped. If fault handler was defined, its code starts execution. (See below for details on fault handler). If there is no fault handler - user program is terminated.

Fault code will be written in DFAULTS register and available to user's program. See list of fault codes in section 2.15

Dedicated "Ready" output will turn OFF.

Any output with assigned special function "fault" will turn ON

Any output with assigned special function "ready/enabled" will turn OFF

LED's located on drive's front panel:

Ready will turn OFF

Status will BLINK OUT fault code or stay ON depending on fault type (See hardware manual section "Faults" for details on fault LED).

Overcurrent will turn ON if fault was "Overcurrent"

Overvoltage will turn ON if fault was "Overvoltage"

Clearing Fault condition can be done one of the following ways:

If user program has Fault Handler section execute RESUME statement at the end (see code example below).

Press <Indexer->Restart> if in MotionView Studio or

Send "Reset" command (command ID= 78) over the Host Interface or

Cycle power (hard reset).

Note:

You cannot execute "ENABLE" command while executing error handler code

You must leave error handler code by executing first "Reset" or "Resume <label>" statements.

Certain statements are not allowed for use in fault handler. See section 2.1 for additional details and Language Reference section for statement ON FAULT/ENDFAULT.

Here is an example:

```
;
;This program handles faults correctly
;
UNITS=1
.
.
.     {Some initialization code}
.


PROGRAM_START:
ENABLE

MOVED 10
MOVED -10
.
.     {Program statements}
.

END
;-------------------------------------------------------------------------
----------
;Fault Handler. If any fault occurs following program will run:
;-------------------------------------------------------------------------
-- -------
ON FAULT        ;statement starts fault handler

.
;Fault handler program. Motion stopped, Drive disabled, events not scanned
;while executing fault handler statements
;
;Do whatever necessary in your system
;after fault is detected. Turn ON/OFF some outputs …etc.
.
.     {Statements}
.

RESUME PROGRAM_START    ;program restarts from label PROGRAM_START
;     RESET                   ;you can use this statement instead.
                              ;to start program from the beginning

ENDFAULT    ;fault handler MUST end with this statement
```

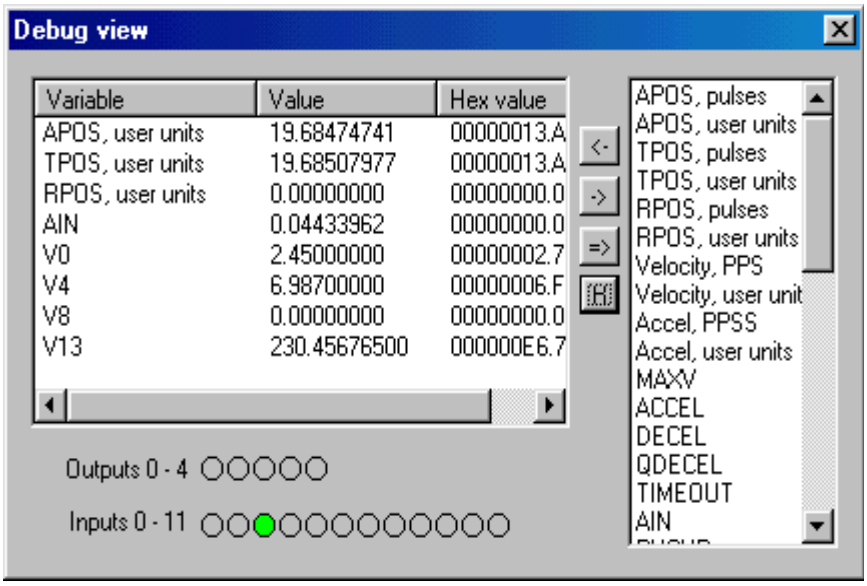
1.5 Using advanced debugging features

Click on <Indexer><Reset> menu to restart program from the beginning.

To execute program statements one at the time use or toolbar buttons or menu: <Indexer> <Step in> (or <Step over>).

If you need to execute program up to certain statement and then stop to for example evaluate variable or check program branching you can set breakpoints.

To set/reset breakpoint click program line you want program to stop at and click toolbar button or use menu <Indexer><Toggle breakpoint>.



To view system and user variables values use menu <Indexer><Show Variables>. Select variables you want to see and click on <R> (Refresh) button to refresh variables values. Note that variables values are refreshed manually when you click on <R> button in the lower right corner or automatically when program stops when single step completed or breakpoint is encountered.

1.6 Inputs and Outputs

Analog Input and Output

SSi has one analog input and one analog output directly accessible from User Program or via Host Interface. Analog input value contained in AIN System Variable. Value returned in AIN lays in range -10 to +10 representing voltage on analog input from -10V to +10V. Analog output can be written by writing to System Variable AOUT. Valid range for AOUT is -10 to +10 resulting in output voltage -10V to +10V output.

Digital Inputs numbering

SSi has 12 inputs for customer connection. Inputs are separated into three groups: A, B and C. Inputs within the group share common terminal. Inputs are named by group name: A1-A4, B1-B4, and C1-C4. In addition to group name, every input has its bit number range from 0 to 11in INPUTS System variable. Each input allocates 1 bit in INPUTS variable. See table below:

Input Name	System Variable INPUTS bit #
A1	0
A2	1
A3	2
A4	3
B1	4
B2	5
B3	6
B4	7
C1	8
C2	9
C3	10
C4	11

Some inputs could have additional special functionality like Travel Limit, Registration etc. Special functions (if appropriate) are selected in MotionView program for execution by Host Interface command(s). Input functionality is summarized in the table below. Input current states are available for programmer through dedicated System Flags or as bits of System Variable INPUTS. Table below summarizes inputs:

Function	Special function
Input A1	Left limit switch
Input A2	Right limit switch
Input 2 A3	
Input 3 A4	
Common for A section	
Input 4 B1	
Input 5 B2	
Input 6 B3	
Input 7 B4	
Common for B section	
Input 8 C1	Master encoder input “A”
Input 9 C2	Master Encoder input “B”
Input 10 C3	Registration sensor input
Input 11 C4	
Common for C section	

Read Digital Inputs

We will now modify our test program to look for the input to go on before doing the first move, and wait for the input to go off before doing second move. Modified program look like this:

```
;This program looks for the input goes on before making first move
;and looks for the input goes off before making second move

DEFINE      INPUT_ON 1
DEFINE      INPUT_OFF 0
UNITS=1
ENABLE
WAIT UNTIL IN_A1==INPUT_ON          ;waits until IN_A1 is ON
;WAIT UNTIL IN_A1 ;you can use this is shorter form ;too
MOVED       10
WAIT UNTIL  IN_A1==INPUT_OFF  ;waits until IN_A1 is OFF
;WAIT UNTIL !IN_A1      ;you can use this is shorter form ;too
MOVED -10
END
```

NOTE: Newly added statements are in blue.

Using inputs to generate predefined indexes

Sometimes it is convenient to use inputs to perform predefined moves (indexes).

To simplify task of inputs processing for such purposes SSi provides special system variable INDEX and keyword ASSIGN. Keyword ASSIGN causes specific input act as particular bit of system variable INDEX . After such assignments changes of input state will cause changes of the particular bit variable INDEX input is assign to. Variable INDEX could be used then conveniently to select predefined move.

…{statements} …

```
ASSIGN  0 AS BIT 7       ;input A1
ASSIGN  1 AS BIT 5  ;input A2
ASSIGN  5 AS BIT 4  ;input A4
```

…{statements} …

Variable INDEX structure after execution of the ASSIGN statements will look like this:

Note that every input can be assigned as any bit position within INDEX variable' lower 8 bits. Bits 8-31 are not used and always set to 0. Not assign bits in INDEX variable are set to 0s.

BITS 8-31 (not used)	A1	0	A2	A4	0	0	0	0

Limit switches input functions

Inputs A1 and A2 have secondary functions as Hard Limit Switch Negative and Hard Limit Switch Positive respectively. From MotionVew's I/O folder you can select what type of action to perform when one of the inputs is activated. Refer to the table below for list of possible actions.

Action	Description
Not Assigned	No action. Input functioning as regular input
Fault	Input activation cause disable and fault
Stop and Fault	Input activation causes deceleration with rate set by System Variable QDECEL and then disable and fault

Digital Outputs Control

There are total of 5 outputs. 4 are general purpose programmable and 1 dedicated.

Dedicated output turns ON when system status is READY and cannot be controlled from the program. The rest of 4 outputs could be assigned special function through MotionView or executing Host Interface commands. You can turn ON (set) or turn OFF (clear) particular output by writing to corresponding System Flag or setting particular bit(s) in System Variable OUTPUT. Output can be control by program if it is not assigned to one of the special functions. In this case, output is controlled internally and changing its value from within program (or via Host Interface) has no effect on output. Table below summarizes outputs functions and corresponding flags in DSTATUS System Variables. To set output write to its flag any non 0 value (TRUE). To clear output write to its flag 0 (FALSE). You also can use flags in expression. If expression evaluates to TRUE then output will be turned ON. It will be turned OFF otherwise.

Example:

```
;Following code sets and clears some outputs
;
      OUT1 =1     ;turn OUT1 ON
      OUT2=10     ;any value but 0 turns output ON
OUT3=0      ;turn OUT3 OFF
OUT2 = APOS>3 && APOS<10      ;ON when position within window
                                    ;OFF otherwise


Function    Related Flag # from DSTATUS System Variable
Motion Complete   25
In Position Window      5
Fault 3
In Motion   Inverse of flag 25
Ready 0
```

1.7 Events

Scanned Events

A Scanned Event is a small program that runs independently of the main program. To establish Scanned Event we need to specify condition to scan in event header and write statements to perform when condition is true. Finally we need to turn Event On by executing Event <eventname> ON statement. To learn more about Scanned Events refer to the Section 2.12. We will use Scanned Events to implement a programmable limit switch. A programmable limit switch is a mechanism that can be programmed to turn on at specific position. We will set up a Scanned Event to check if the current position (system variable APOS) is greater than or equal to a given value (3) and less than or equal to another given value (6). If it is, Output 0 is turned ON. Otherwise it is OFF.

```
UNITS =1
;
;
EVENT       InLimits    1==1  ; always true so event scanned every
;256uS
                              ;
OUT1= APOS>=3  &&  APOS<=6
                              ;
ENDEVENT
;
ENABLE                        ;APOS and TPOS are initialized to 0
EVENT  InLimits  ON           ;turns Event InLimits ON
;Make some moves so we can go in and out ;of the specified limits of
      MAXV=200                ;200 Rpm
      ACCEL=10                ;10 Rps*s
DECEL=10                ;same as ACCEL


ProgramStart:
MOVE  10                      ;move to 10 revs position
MOVE  0                       ;move back to 0
GOTO ProgramStart             ;loop it forever
END
```

When this program run motor will move 10 revs CW and than move back to initial position. Output 0 will be ON during motor shaft position within the window 3 to 6 revs inclusively and low all the other times. There are certain restrictions when writing code for event handlers. Refer to section 2.1 for additional information on scanned events.

1.8 Variables and Define statement

In the previous program for programmable limit switch we used hard coded numbers 3 and 6 :

```
EVENT       InLimits    ALWAYS      ;scanned every 256uS
      ;
      OUT1=APOS>=3  &&  APOS<=6     ;Hard Coded Limit values
ENDEVENT
```

Using hard coded numbers is fine as long as these numbers are known at the moment when you preparing program. (Or we call it "at compile time").But what if limits has to be calculated based on some parameters unknown before program run? (i.e. home origin, material width etc.). Then you can use User Variables instead of hard coded values. SSi has 32 User Variables available for calculation and storage of intermediate data. Let's use variable V1 and V2 to hold the values of lower and upper travel limits:

```
;Modified program:
EVENT       InLimits    ALWAYS      ;scanned every 256uS
      ;
OUT1= APOS>=V1  &&  APOS<=V2  ;Variables hold Limit values
ENDEVENT
```

It might be difficult to remember that V1 is the lower and V2 is upper travel limit later on. The DEFINE statement lets a programmer define a meanful name to a variable. The program looks like this:

```
DEFINE      LowerLimit  V1          ;name alias for V1
DEFINE      UpperLimit  V2          'name alias for V2
Define      ALWAYS      1
EVENT       InLimits    ALWAYS      ;scanned every 256uS
      ;
OUT0=APOS >= LowerLimit  &&  APOS <= UpperLimit ;Variables V1 V2
;named by DEFINE statement
ENDEVENT
```

1.9 IF/ELSE statements

IF/ELSE statement allows you to execute one or more statements conditionally. You can use IF or IF/ELSE construct:

Single IF example:

;Implementing counter modulo reset:

```
Again:
      V1=V1+1
      IF   V1>10
V1=0
      ENDIF
      GOTO Again
END
```

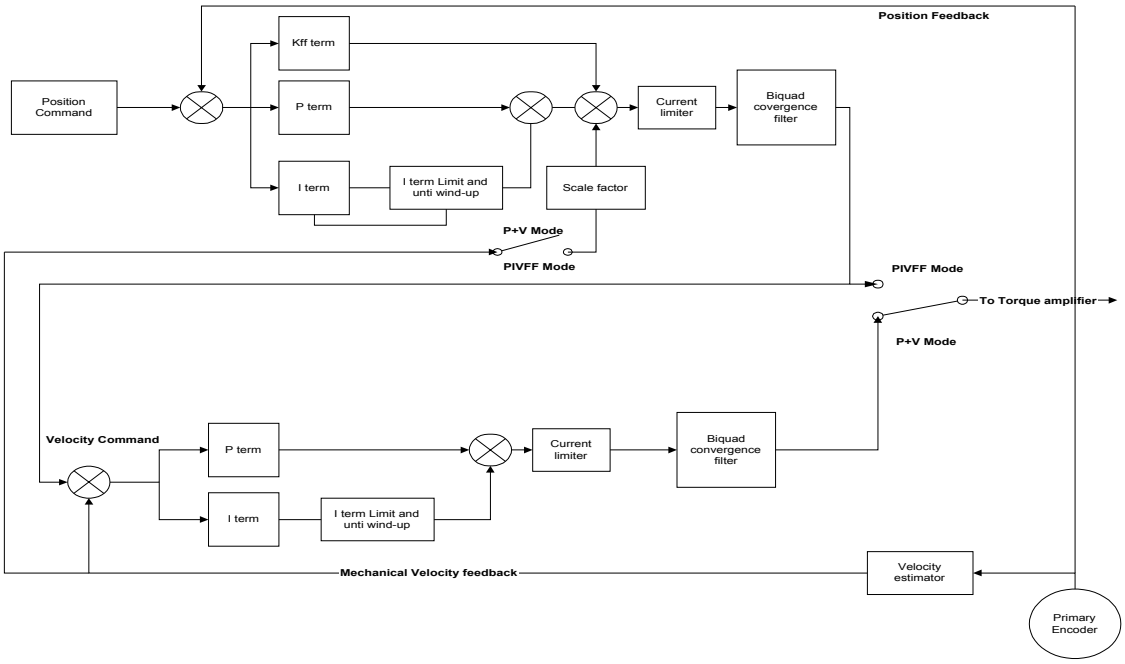
IF/ELSE example:

```
;Assign value to variable conditionally
      IF V1>3
            V2=1
      ELSE
            V2=0
      ENDIF
```

IF or IF/ELSE construct **must end** with ENDIF keyword

1.10 Motion

SSi position and velocity regulator's diagram



"Position Command" in regulator's diagram is produced by trajectory generator. Trajectory generator processes generated motion commands, produced by User's program motion statements, in order to calculate position increment or decrement or also called "index" value for every servo loop. This way target (or theoretical) position supplied to regulator input. The main job of the regulator is to control motor shaft torque and velocity such way that actual position of the motor shaft, measured by processing motor's encoder position feedback, matches target position as closed as possible. Of course there is always will be the error in position following. Such error called "Position Error" and is expressed as:

Position Error = Target Position - Actual Position

When Position Error exceeds certain threshold value "Position Error Excess" fault #7 will be generated. You can set allowable Position Error limit and Position Error Time (how long is a delay before fault generated). These parameters can be set only using MotionView software.

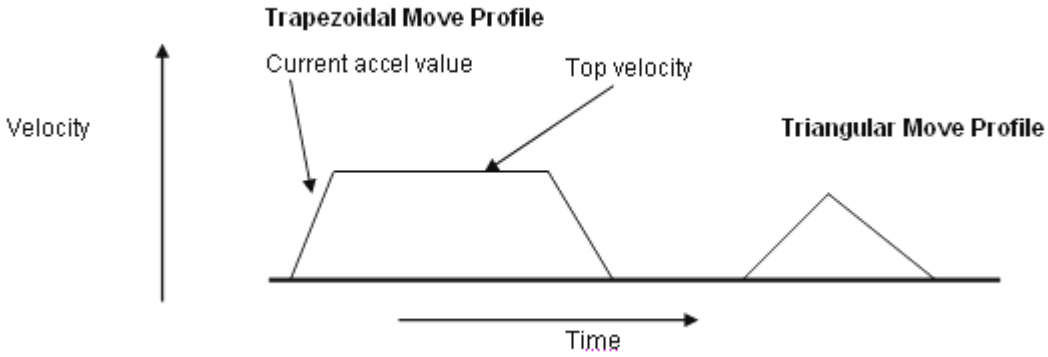
Motion Modes

There is three modes SSi can operate in: Indexing (profiling) mode, Velocity mode and Gear mode. Indexing is a default mode. All user program generated moves are executed in this mode. Velocity and Gearing mode are covered in details in section 2.13.

Point To Point Moves

SSi supports two types of moves: absolute and incremental. The statement MOVEP (Move to Position) is used to make absolute move. The statement MOVED (Move Distance) makes incremental (or relative) move from current position.

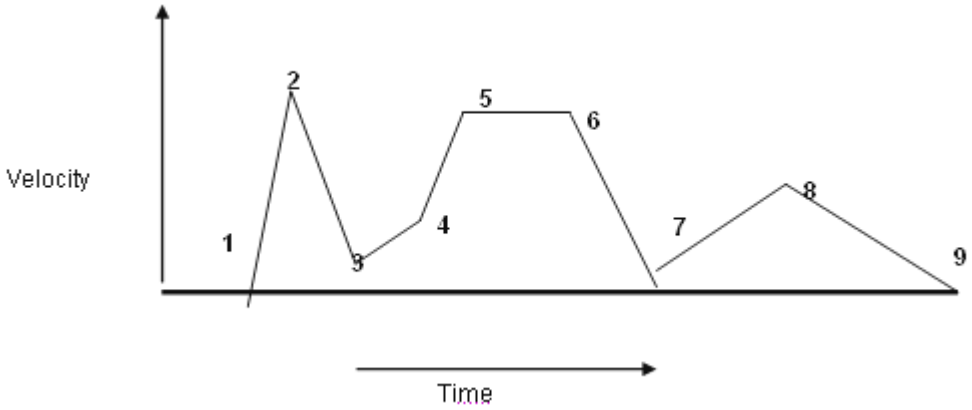
MOVEP and MOVED statements generate what is called a trapezoidal point to point motion profile: the motor accelerate using the current acceleration setting to a default top speed and then decelerate at the right time to arrive at desired position. If the distance to be moved is fairly small, a triangular move profile will be used: the motor will accelerate for the half the move and decelerate for the other half of the move, but never reach the top speed.



Segment moves

MOVED and MOVEP commands are simple and useful, but if the required move profile is more complex then a simple trapezoid, MDV (segment) moves can be used.

The profile shown below can be broken up to 8 MDV moves. The first segment would define the distance between point 1 and point 2 and the velocity at point 2. So, if the distance between point 1 and 2 was 3 units and the velocity at point 2 was 56 RPM, the command would be: MDV 3 , 56. The second segment would give the distance between point 2 and 3 and the velocity at point 3, and so on. Any profile can be programmed using MDV moves.



From the following table, write a program to execute the move profile shown, and run it.

Segment Number	Distance moved during segment	Velocity at the end of segment
1	3	56
2	3	12
3	4	16
4	2	57
5	2.5	57
6	3	11
7	5	20
8	5	0
-	-	-

-

```
;Segment moves
MDV   3 , 56
MDV   3 , 12
MDV   4 , 16
MDV   2 , 57
MDV   2.5 , 57
MDV   3 , 11
MDV   5 , 20
MDV   5 , 0
END
```

Registration

Both type of moves absolute and incremental could be used for registration moves. Statements MOVEPR and MOVEDR perform registration moves. Statements have two arguments. First argument specifies move distance or position and second specifies displacement from registration position if it is detected. SSi has input which registration sensor could be connected to. Move initiated by <<MOVEDR 10,30 >> will result in incremental motion to 10 user units if registration mark is not met. Otherwise motion will continue to "Registration position" + 30 user units.

S-Curve Acceleration

Very often it is important for a move profile to be as smooth as possible. This could be to minimize the wear on a machine, or it could be that a smooth profile is critical to the successful completion of an operation. To perform smooth motion profiles, the Sis supports S-curve acceleration.

With normal, straight line acceleration, the axis is accelerated to the target velocity in a linear fashion. S curve acceleration accelerates axis slowly at the first, twice as fast as the straight line acceleration in the middle, and then slowly stops accelerating. With straight line acceleration, the acceleration changes abruptly and then at the end of acceleration period, changes abruptly again to no acceleration. With S-curve acceleration the acceleration gradually builds to the peak value the gradually decreases to no acceleration. The disadvantage with S-curve acceleration is that for the same acceleration distance the peak acceleration is twice that of straight line acceleration - which often requires twice the peak torque. Notice that the axis arrive at the target position at the same time regardless which type of acceleration is used.

To use S-curve acceleration in MOVED,MOVEP or MDV statement requires only the additional ",S" at the end of the statement.

Examples:

MOVED	10 , S
MOVEP	10 , S
MDV	10,20,S
MDV	10,0,S

Motion Queue

By default when program executes MOVE, MOVED or MOVEP statements, it waits motion complete before to go to the next statement. This effectively will suspend the program until requested motion is done. Note that event are not suspended however and keep on executing in parallel. While this is convenient for simple motion program it could be a troublesome when trying to do monitoring and controlling I/O at the same time when execute motion. Consider a short program:

```
;This program monitors I/O in parallel with motion:
START:
      MOVED 100,C             ;start moving max 100 revs
WHILE  FLAG_MOTION            ;while moving
      IF IN_A2 == 1           ;if sensor detected
            OUT1=1            ;turn ON output for
            WAIT TIME 10      ;10 mS
            OUT1=0            ;turn output OFF
      ENDIF
ENDWHILE
;Return mechanism back
      MOVED    -100           ;Return back
      WAIT TIME 1000          ;wait time
      GOTO START              ;and start all over
      END
```

This program starts motion and moves for maximum 100 revs. While in motion if it sees sensor (or switch) it turns output for 10mS. The programs able to look for the sensor while executing motion because of ",C" modifier for MOVED statement. Without this modifier program would be suspended until all motion is done making impossible to look for the sensor on input #1. After it travels the full distance it returns back to initial position and process repeats. This program could be used for simple paint mechanism which turns ON paint spray as soon as part edge (or part guide) crosses the sensor(s).

On the other hand, MDV statement execution never suspends the program because each individual statement sets portions of motion profile. Every motion profile or portion of (in case of MDV statement) generated by motion statements MOVEP,MOVED or MDV first go to motion stack and than executed one by one. In the other hand if statement doesn't have ",C" modifier motion profile generated by this statement goes to motion stack and program suspended until this profile has been executed.

1.11 Subroutines and Loops

Subroutines

Often it is necessary to repeat a series of steps in several places in a program. Subroutines can be useful in such situations. The syntax of a subroutine is simple. Subroutines must be placed after the main program (after END statement), must start with subname: label (where subname is name of subroutine), and must end with a statement RETURN.

Note that it can be more than one RETURN statement in a subroutine. Subroutines are called using the GOSUB statement.

Loops

SML language supports WHILE/ENDWHILE block statement which can be used to create repetition loops. Note that IF-GOTO statements can also be used to create loops.

Following example shows a subroutine called MDS and WHILE/ENDWHILE block statement to implement looping.

```
      DEFINE      LOOPCOUNT   V1
      DEFINE      LOOPS       10
      DEFINE      dist        V2
      DEFINE      repetitions V3

      repetitions=0
MainLoop:
      LOOPCOUNT=LOOPS
      dist=10
      WHILE       LOOPCOUNT         ;inner performs LOOPS times
            dist=dist/2
            GOSUB MDS               ;Call to subroutine
            WAIT        100         ;this executes when returned
;from subroutine
            LOOPCOUNT=LOOPCOUNT-1   ;decrement loop counter
      ENDWHILE
      repetitions=repetitions+1     ;outer loop
      IF    repetitions < 5
goto main
      ENDIF
END
;-------------------Main program End--------------------------------
;------------------------------------------------------------------
;Motion subroutine
;-------------------------------------------------------------------------------
--
MDS:
      V4=dist/3
      MDV   V4, 10
      MDV   V4,10
      MDV   V4,0
RETURN
```

2. Programming

2.1 Introduction

One of the most important aspects of programming is developing a structure for the program. Before you begin to write a program, you should develop a plan for that program. What tasks must be performed? In what order do they need to be performed? What things can be done to make the program easy to understand and to be maintained by others? Are there any procedures that are repetitive?

Most programs are not a simple linear list of instructions where every instruction is executed in exactly the same order each time program run. Programs need to do different things in response to external events and operator input. SML contains program control structures instructions and scanned event functions that may be used to control the flow of execution in an application program.

Control structure instructions are the instructions that cause the program to change the path of execution. Scanned events are instructions that execute at the same time as the main body of the application program.

Program Structure

SML programs are divided into four distinct sections:

Header

```
DEFINE      name  Vn
ASSIGN
```

Events description

```
EVENT       name  <condition>
      …statements
ENDEVENT
```

Main Program Body

```
      …statements
;End of main body statements
END
```

Subroutines

```
SUB   subname
      …statements
RETURN
Fault handler
ON FAULT
      …statements

      RESUME <label>

ENDFAULT
```

The header section of the program contains definitions of the names for user variables and constants used in the program. If none of these are used in a program the header section is not required.

Events sections contain all scanned events sections. Remember to execute EVENT <eventname> ON statement in main program to enable events. Not all statements are possible to use within event body. See EVENT/ENDEVENT statement in Language Reference section for details on the statements restrictions. While GOTO statement is prohibited within event code, you can use JUMP statement to jump to code in main program body. You can use such technique if you need to change program flow by occurrence of the event. See JUMP statement in Language Reference section for details.

The main program body of the program contains the main part of the program, which can include all motion and math statements, labels, I/O commands and subroutine calls. Main body has to be finished with END statement.

Subroutines are routines hat are called from the body of the program. When a subroutine is called, program execution is transferred to the subroutine until a RETURN statement occurs. Then, program execution returns to the body of the program following the GOSUB statement.

Fault handler is the special section of the program embraced with ON FAULT and ENDFAULT statements. When any fault occurred normal program flow will be interrupted and statements in fault handler will start to execute. When fault occurs the motion (if any) will be stopped and drive will be disabled. Events scanning will be stopped until program exits fault handler. Fault handler can be terminated two ways:

Using RESUME <label>.Statement will end fault handler end start execute code from location named in <label>. Using RESET statement. Statement will reset program execution from first statement.

If ENDFAULT statement is met before RESET or RESUME statements user program will be terminated. Fault handler should be kept as short as possible. If You need extensive processing of the fault create such code in main program and make RESUME <label> as soon as possible. While fault handler is active events are not being processed and detection of the other faults is not possible. Not all statements can be used while program in the fault handler. See ON FAULT/ENDFAULT statement description in Language Reference section for details.

Comments are allowed in any section of the program and are preceded by a semicolon. They may occur on the same line as an instruction, or on a line that contains only the comment. Any text following a semicolon on a line will be ignored by the compiler.

2.2 User Variables

SML supports a fixed set of variables that the programmer can use to store data and perform arithmetic. All user variables are of a single type(see below). Single type variables facility (typeless variables) relieve programmer of the task to remember and apply conversion rules between types, thus greatly simplifying programming.

Since SML is typeless language, there is no special type for Boolean type variables (variables that can be only 0 or 1). Regular variables are used to facilitate Boolean variables. When assigning 0 value to variable it is evaluated as "FALSE" in logic equations and non 0 value evaluates as "TRUE".

In addition to the user variables, system variables are also supported.

System variables are dedicated variables that contain particular values. For example, APOS contains actual position of the motor shaft. System variables are discussed later in chapter "System Variables and Flags".

Scope

SML variables are available system wide. Each of the variables can be read and set from any user program, subroutine or Host Language Command at any time. There is no provision to protect a variable from change. This is referred as global scope.

Volatility

All Sis variables are volatile i.e. they don't maintained their values after power is removed. After power up values of all variables are set to 0. Program load or reset doesn't change variables values.

Flags, Resolution and Accuracy

As mentioned before you can use any variable as flags in logical expressions and as conditions in conditional expressions. Flags are often used to indicate that some event has occurred, logic state of input has changed or that the program has executed to a particular point. Variables with non 0 value are evaluated as "TRUE" and with 0 value as "FALSE".

Variables are stored internally as 4 bytes (double word) for integer portion and 4 bytes (double word) for fractional portion. This way every variable in SSi system stored as 64 bit in 32.32 fixed point format. Maximum number can be represented by this format is +/- 2,147,483,648. Variable resolution in this format is 2.3E-10.

2.3 Arithmetic's

Four arithmetic functions are supported. Constants, User and System variables could be part of arithmetic expressions.

Examples.

```
V1 = V1+V2          ;Add two user variables
V1 = V1-1           ;Subtract constant from variable
V2 = V1+APOS        ;Add User and System (actual position) variables
APOS = 20           ;Set System variable
V5 = V1*(V2+V3*5/2+1) ;Complicated expression
```

Operator	Symbol
Addition	+
Subtraction	-
Multiplication	*
Division	/

Result overflow for "*" and "/" operations will cause Arithmetic overflow fault # 19. Result overflow/underflow for "+" and "-" operations ***does not cause*** arithmetic fault.

2.4 Logical expressions and operators

Bitwise, Boolean, and comparison operators are considered as Logical Operators. Simply put they are the operators which operate on logical values of the operands. There are two possible values for logical operand: TRUE and FALSE. Any value contained in User or System variable or flag treated as TRUE or FALSE with these types of the operators. If variable value equal 0 it is considered FALSE. All the other values (non 0) including negative numbers are considered TRUE.

2.5 Bitwise operators

The following bitwise operators are supported

Operator	Symbol
AND	&
OR	|
XOR	^
NOT	!

Both User or System variables can be used with these operators.

Examples:

```
V1 = V2 & 0xF     ;clear all bits but lowest 4
IF  (INPUTS & 0x3)      ;check inputs 0 and 1
V1 = V1 | 0xff          ;set lowest 8 bits
V1 = INPUTS ^ 0xF   ;invert inputs 0-3
V1 = !IN_A1                    ;invert input 0
```

2.6 Boolean Operators

These operators are used in logical expressions.

Operator	Symbol
AND	&&
OR	||
NOT	!

Examples:

```
IF APOS >2 && APOS <6 || APOS >10 && APOS <20
      . {statements if true}
ENDIF
```

Above example check if APOS(actual position) within one of two windows:

2 to 6 units or 10 to 20 units. In plain English:

"If APOS more then 2 AND APOS less then 6 OR APOS more then 10 AND APOS less then 20 -----à then evaluate to TRUE. Otherwise it is FALSE"

2.7 Comparison operators

Following operators are supported:

Operator	Symbol
more	>
less	<
Equal or more	>=
Equal or less	=<
Not Equal	<>
Equal	==

Examples:

```
IF APOS <=10
IF APOS > 20
IF APOS ==5
IF  V1<2  && V2 <>4
```

2.8 Summary of User Variables

V0-V3 User defined variables. Variables can hold any numeric value including logic (Boolean 0 - FALSE and non 0 - TRUE) values. They can be used in any valid arithmetic or logical expressions.

N0-N31 User defined network variables. Variables can hold any numeric value including logic(Boolean 0 - FALSE and non 0 - TRUE) values. They can be used in any valid arithmetic or logical expressions. Variables can be shared across Ethernet network with use of statements SEND and SENDTO.

2.9 System Variables and Flags

System variables are variables that have a predefined meaning. In most cases the value of these variables can be read and set in your program. Many of these variables can be set in folders of Motion View. Some of the variables are read only write only or read and write. Read only variables cannot be used as left value of the expression. For instance INPUT = 5 is illegal because you can not set inputs.

System Flags are the special System variables that can only have values 0 or 1. As an example, IN_A1 is the system flag and reflects state of the digital input1. Input only can be 0 or 1 and therefore flag IN_A1 will have values 0 or 1.

2.10 System Variables and Flags Summary

Below is the table of System Variables and Flags, sorted by type. Variables can be Read-Only (R) or Read/Write (R/W) types. System Flags are always Read Only (R).

Variable	Access	Variable Description	Units
UNITS	R/W	User Units scale.**NOTE 1	UserUnits/Rev
APOS	R/W	Actual motor position	User Units
TPOS	R	Theoretical/commanded position	User Units
TV	R	Commanded velocity in	User Units/Sec
RPOS	R	Registration position. Valid when system flag F_REGISTARTION set	User Units
TA	R	Commanded acceleration	
INPOSLIM	R/W	Maximum allowable deviation of position for INPOSITION Flag to remain to be set	User Units
MAXV	R/W	Maximum velocity for motion commands	User Units/Sec
ACCEL	R/W	Acceleration for motion commands	User Units/Sec^2
DECEL	R/W	Deceleration for motion commands	User Units/Sec^2
QDECEL	R/W	Quick Deceleration for STOP MOTION QUICK statement	User Units/Sec^2
VEL	R/W	Set Velocity when in velocity mode	User Units/Sec
GRATIO	R/W	Gear Ratio between master encoder and motor	-
MEPPR	R/W	Master Encoder resolution.	Pulses
PGAIN_P	R/W	Position loop P-gain	-
PGAIN_I	R/W	Position loop I-gain	-
PGAIN_D	R/W	Position loop D-gain	-
PGAIN_VFF	R/W	Position loop VFF (velocity feed forward) gain	-
PGAIN_ILIM	R/W	Position loop I gain limit	-
VGAIN_P	R/W	Velocity loop P-gain	-
VGAIN_I	R/W	Velocity loop I-gain	-
INPUTS	R	Digital Inputs states. First 12 bits corresponds to 12 SSi inputs	-
OUTPUTS	R/W	Digital outputs. First 5 bits represents outputs From #0 to #4	-
INDEX	R/W	Lower 8 bits are used. See ASSIGN statement for details.	-
PHCUR	R	Motor phase current	A(mpere)
DSTATUS	R	Status flags register	-
DFAULTS	R	Fault code register	-
AIN	R	Analog input. Scaled in volts. Range form –10 to +10	V(olt)
AOUT	R/W	Analog output value in Volts. Valid range from –10 to +10 (V) NOTE 2	V(olt)

NOTE 1

If 0 (Zero) value assigned to variable UNITS set USER UNITS to QUAD ENCODER COUNTS. This is default units at the start of the program before UNITS=<value> executed.

NOTE 2

Any value outside +/- 10 range assigned to AOUT will be automatically trimmed to that range.

Example: `AOUT=100 , AOUT will be assigned value of 10.`

```
V0=236
VOUT=V0, VOUT will be assigned 10 and V0 will be unchanged.
```

System Flags

IN_A1-4, IN_B1-4, IN_C1-4	R	Digital inputs . TRUE if input active, FALSE otherwise
OUT1,OUT2,OUT3 OUT4, OUT5	W	Digital outputs OUTPUT1- OUTPUT5
F_ICONTROLOFF	R	Interface Control Status (ON/OFF) #27 in DSTATUS register
F_IN_POSITION	R	TRUE when Actual Position (APOS) is within limits set by INPOSLIM variable and motion completed NOTE 1
F_ENABLED	R	Set when drive is enabled
F_EVENTSOFF	R	Events Disabled Status (ON/OFF) #30 in DSTATUS register
F_MCOMPLETE	R	Set when motion is completed and there is no motion commands waiting in the Motion Queue
F_MQUEUE_FULL	R	Motion Queue full
F_MQUEUE_EMPTY	R	Motion Queue empty
F_FAULT	R	Set if any fault detected
F_ARITHMETIC_FLT	R	Arithmetic fault
F_REGISTRATION	R	Set when registration mark was detected. Content RPOS variable is valid when this flag is active. Flag resets by any registration moves MOVEPR,MOVEDR or by command REGISTARTION ON
F_MSUSPENDED	R	Set if motion suspended by statement MOTION SUSPEND

NOTE 1

Flag logic is shown below :

```
If
   TPOS-INPOSLIM  < APOS <  TPOS+INPOSLIM  && F_MCOMPLETE && F_MQUEUE_EMPTY

      F_IN_POSITION = TRUE
Else
F_IN_POSITION = FALSE

End If
```

For VELOCITY and GEAR mode F_MCOMPLETE and F_MQUEUE_EMPTY flags are ignored and assumed TRUE.

2.11 Control Structures

Control structures allow you to control the flow of your program's execution. Most of the power and utility of any programming language comes from its ability to change statement order with structure and loops.

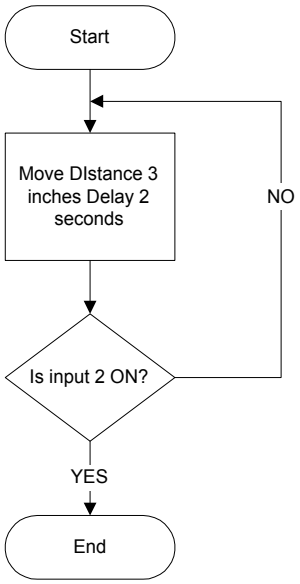
DO/UNTIL structures

This statement is used to execute a block of code one time and then continue executing that block until a condition becomes true (satisfied). The difference between DO/UNTIL and WHILE statements is that the DO/UNTIL instruction tests the condition after the block is executed so the conditional statements are always executed at least one time. The syntax for DO/UNTIL statement is:

```
      DO
            …statements

      UNTIL  <condition>
```

The following flowchart and code segment illustrate the use of the DO/UNTIL statement.

```
… statements

DO
            MOVED 3
            WAIT TIME 2000
UNTIL   IN_A3

…statements
```



WHILE Structure

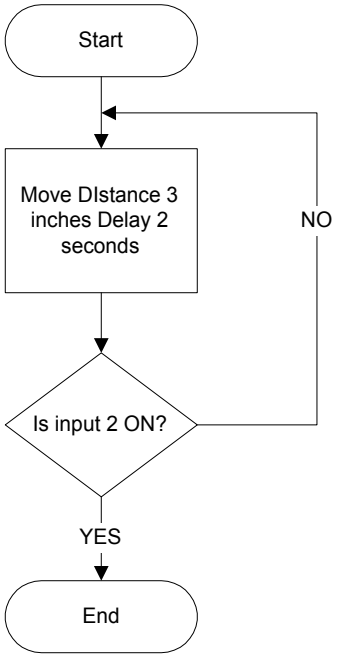
This statement is used if you want a block of code to execute while a condition is true.
The syntax for the WHILE instruction is:

```
        WHILE  <condition>

                …statements

ENDWHILE
```

…statements

```
WHILE    IN_A3
                MOVED          3
                WAIT TIME      2000
ENDWHILE
```

…statements



Subroutines

A subroutine is a group of SML statements that is located at the end of the main body of the program. It starts with label which is used by GOSUB statement to call this subroutine and ends with RETURN statement. The subroutine is executed by using GOSUB statement in the main body of the program. Subroutines can not be called from EVENT or FAULT handlers.

When a GOSUB statement is executed, execution is transferred to the first line of the subroutine. The subroutine is executed until a RETURN statement is met. When the RETURN is executed, program execution returns to the program line in the main program following GOSUB statement. Subroutines may have more then one RETURN statement in its body.

Subroutine may be nested for up to 16 times. Only the remaining body of the program may contain a GOSUB statement. Refer to Part 3 Language Reference for more detailed information on the GOSUB and RETURN statements. The following flowchart and code segment illustrate the use of subroutines.

```
…statements

GOSUB CalcMotionParam
MOVED V1
OUT2=1

…statements

END

;Subs usually located after END
;statement of main program
;

CalcMotionParam:
V1 = (V3*2)/V4
RETURN
```

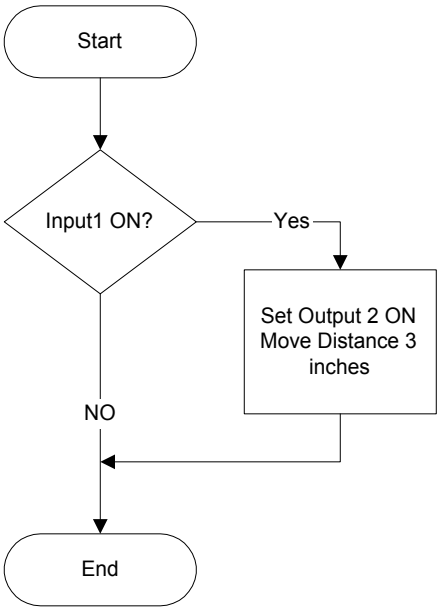
IF Structure

The if statement is used to execute an instruction or block of instructions one time if a condition is true. The simplified syntax for IF is:

```
IF condition
      …statement(s)
ENDIF
```

The following flowchart and code segment illustrate the use of the IF statement.

```
…statements

IF IN_A2
      OUT2 = 1
      MOVED 3
ENDIF

..statements
```



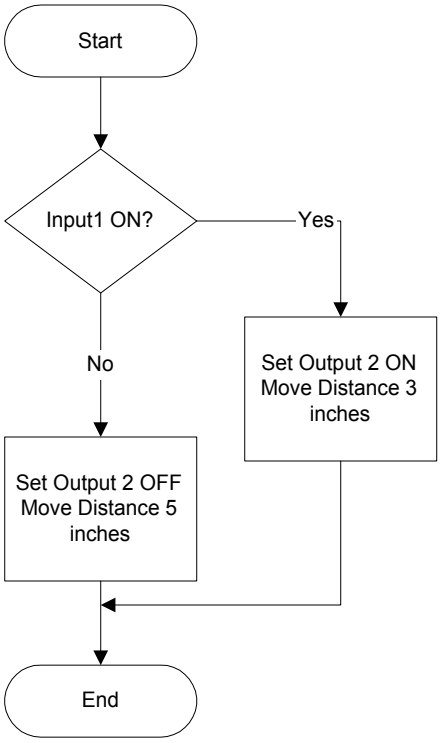
IF/ELSE Structure

The IF/ELSE statement is used to execute an statement or a block of statements one time if a condition is true and a different statement or block of statements if condition is false.

The simplified syntax for the IF/ELSE statement is:

```
IF <condition>
        …statement(s)
ELSE
        …statement(s)
ENDIF
```

The following flowchart and code segment illustrate the use of the IF/ELSE instruction.




```
…statements

IF IN_A2
        OUT2=1
        MOVED 3
ELSE
        OUT2=0
        MOVED 5
ENDIF

..statements
```

WAIT Statement

The WAIT statement is used to suspend program execution until or while a condition is true. The simplified syntax for this statement is:

```
WAIT    UNTIL  <condition>
WAIT    WHILE <condition>
WAIT    TIME    <time>
WAIT    MOTION COMPLETE
```

GOTO/Label

The GOTO statement can be used to transfer program execution to a new point marked by a label. This statement is often used as the action of an IF statement. The destination label may be above or below the GOTO statement in the application program.

Labels may be any alphanumeric string 64 characters in length beginning with a letter and followed by a colon ":".

```
GOTO TestInputs
        …statements

TestInputs:
…statements

IF (IN_A1) GOTO TestInputs
```

Program Structure Instruction Summary

The following table contains a summary of instructions that relate to program branching.

Name	Description
GOTO	Call a subroutine
DO/UNTIL	Do once and keep doing until conditions becomes true
IF and IF/ELSE	Execute if condition is true
RETURN	Return from subroutine
WAIT	Wait fixed time or until condition is true
WHILE	Execute while a condition is true

2.12 Scanned Event Statements

Scanned event statements establish conditions that are scanned on regular basis. SSi scans events every 256uS. Scan and Scan rate independent of main program timing or conditions. Once established, the scanned event can be enabled or disabled in the main body of the application program, in another event or itself (see explanations below). If condition is true, and the scanned event is enabled, when scanned, the specific action(s) is (are) executed.

Scanned events are used to record events and perform actions independent of the main body of the program. For example, if you want output 3 to come ON when the position is greater then 4 inches, or if you need to turn an output 4 ON whenever input 2 and 3 are ON, you may use the following scanned event statements.

```
EVENT       PositionIndicator APOS > 4
            OUT3=1
ENDEVENT

EVENT       Inputs3and4       IN_A4 & IN_B1
            OUT 4=1
ENDEVENT

…statements
```

Scanned events may also be used with timer to perform an action on the periodic time basis.

The program statements contained in the action portion of the scanned event can be any legal program statement except: Subroutine calls (GOSUB), DO/WHILE, WHILE, WAIT, GOTO and also motion commands: MOVED,MOVEP,MDV,STOP, MOTION SUSPEND/RESUME.

EVENT <name> INPUT <inputname> RISE/FALL

The scanned event statement is used to execute block of code every time when specified input <inputname> changes its state from low->hi (RISE) or from hi->low (fall).

EVENT <name> TIME <timeout>

The scanned event statement is used to execute block of code with repetition rate specified by <timeout> argument.

EVENT <name> expression

The scanned event statement is used to execute block of code when expression evaluates to true.

EVENT <name> ON/OFF

This statement is used to enable/disable scanned event. Statement can be used within event's block of code.

Scanned Event Statements Summary

The following table contains a summary of instructions that relate to scanned events.
Refer to Part 5 * Language Reference for more detailed information.

Name	Description
EVENT <name> ON/OFF	enable / disable event
EVENT <name> INPUT <inputname> RISE/FALL	Scanned event on input <#> RISE/fall
EVENT <name> TIME <value>	Periodic event with <value> repetition rate.
EVENT <name> expression	Scanned event on expression = true

2.13 Motion

Motion modes

There is three modes SSi can operate in: **Indexing (profiling) mode, Velocity mode and Gear mode.**

Indexing (profiling) mode is default SSi mode. In this mode SSi can execute all position commands and profiled moves described below in this chapter.

In velocity mode SSi moves with designated acceleration deceleration and velocity set by internal user accessible variables: ACCEL, DECEL and VEL respectively. Current position values are in tacked in this mode and any calculation based on actual and target position are valid. To place SSi in this mode execute VELOCITY ON statement. To exit velocity mode execute VELOCITY OFF statement.

In Gear mode SSi follows master encoder connected to SSi dedicated encoder inputs.

User can select resolution of the master encoder and gear ratio. Current position values are valid in this mode and any calculation based on actual and target position are valid. To place SSi in this mode execute Gear ON statement. To exit Gear mode execute GEAR OFF statement.

Moves Overview

Position commands that cause motion to be generated comes from profile generator or profiler for short. The profile generator is used by MOVE, MOVED, MOVEP, MOVEPR, MOVEDR and MDV statements. MOVE commands generate motion in positive or negative direction while or until conditions are met. For example you can specify motion until specific input remains ON (or OFF). MOVEP generates move to specific absolute position. MOVED generates incremental distance move i.e. move some distance from current position. MOVEPR and MOVEDR are registration moves. MDV commands are used to generate complicated profiles. Profiles generated by these commands are put into the motion stack which is 32 levels deep. By default when one of these statements (except MDV) is executed, program suspends until motion generated by that command is done. Motion requests generated by MDV statement or if MOVE statements with ",C" modifier doesn't suspend the program. They are merely put in the motion stack and executed by profiler in the order they where put. It is the responsibility of the programmer to check if space in the motion stack is available by checking appropriate flag in System status register.

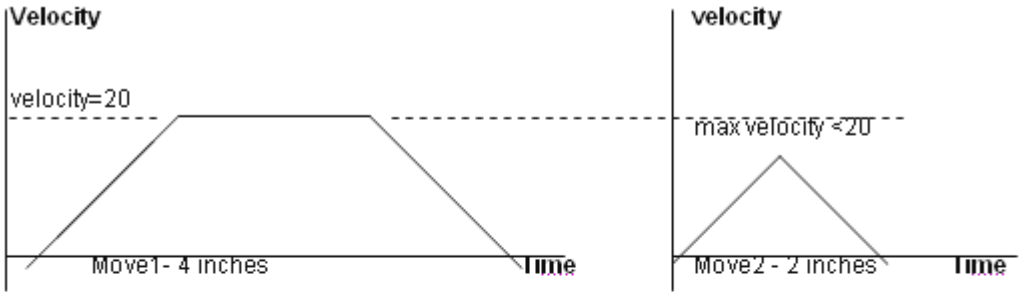
Incremental (MOVED) and Absolute (MOVEP) Motion

MOVED and MOVEP statements are used to create incremental and absolute moves respectively. The motion that results from these commands is by default a trapezoidal velocity move or S-curved velocity move if ",S" modifier is used with the statement,
For example:

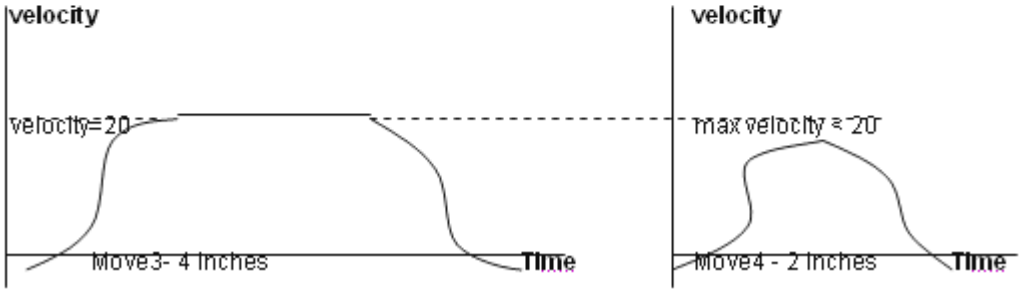
```
MOVEP 10      ;will result in trapezoidal move
But
            MOVEP 10,S   ;will result in S-curved move
```

The length of the move is determined by an statement's required argument. Argument can be any valid arithmetic expression. The top velocity of the move is determined by setting system variable MAXV. The acceleration and deceleration are determined by system variables ACCEL and DECEL respectively.

If values of velocity, acceleration and deceleration are such that for specified distance there is not enough time to accelerate to specified velocity, motion profile will result in triangular or double S profile. (see picture below"



Trapezoidal moves




```
ACCEL =  200
DECEL =  200
MAXV  = 20
MOVED       4     ;move 1
MOVED       2     ;move 2
MOVED 4 , S ;move 3
MOVED 2 , S ;move 4
```

In example above the acceleration, deceleration and velocity where equal, but the distances where different. In the move 1 and 3 the peak velocity reached the specified velocity of 20. In move 2 and 4 the profile changed with max velocity less than specified.

Incremental (MOVED) motion

Incremental motion is defined as a move of some distance from the current position. Move four revolutions from the current position is an example of an incremental move.

MOVED is the statement to create incremental moves. The simplified syntax is:

MOVED <+/-distance>

+/- sign will tell the direction motor shaft is moving.

Absolute (MOVEP) move

Absolute motion is defined as a motion to some fixed position from the current position. The fixed position is defined as a position relative to a fixed zero point. The zero point for a system is established during homing cycle, typically performed immediately after power-up.

During a homing cycle, the motor will make incremental moves while checking for a physical input, index mark, or both.

Registration (MOVEDR MOVEPR) moves

MOVEPR and MOVEDR used to move to position or distance respectively just like MOVEP and MOVED. Difference is that when executed they looking for the registration signal on registration input. If during the motion registration signal is detected then commands add displacement specified in command parameter field to position where registration signal is met and modify current move to end at this new position.

Example:

MOVEDR 5, 1 ; Statement move distance of 5 user units or registration position + ;1 user units if registration input is activated during motion.

There is two exceptions from this behavior.

Exception one:

Move will not be modified to "Registration position +displacement" if registration detected while system already in decelerating phase to complete motion.

Exception two:

The distance "Registration position+displacement" must be at least more then distance to stop with selected deceleration rate from velocity at the time when registration occurs.

If this distant is smaller, system will overshoot final desirable position.

Segment moves

In addition to the simple moves that can be generated by MOVED and MOVEP statements, complex profiles can be generated using segment moves. A segment move represents one portion of a complete move. A complete move is constructed out of two or more segments, starting and ending at zero velocity.

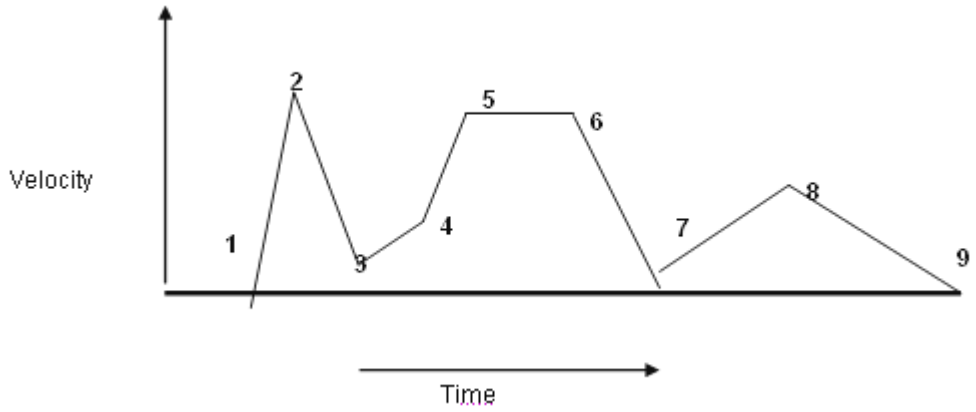
MDV Segments

Segments are created using a sequence of MDV statements. The simplified syntax for the **MDV** (**M**ove **D**istance with **V**elocity) statement is:

MDV <**d**istance>,<**v**elocity>

The <distance> is the length of the segment move. The <velocity> is the final velocity for the segment move. The starting velocity is either zero or final velocity of the previous segment. The final segment in a complete move must have a velocity of zero. If final segment has final velocity anything else then zero motion stack underrun fault will occur.

The profile shown below can be broken up to 8 MDV moves. The first segment would define the distance between point 1 and point 2 and the velocity at point 2. So, if the distance between point 1 and 2 was 3 units and the velocity at point 2 was 56 RPM, the command would be: MDV 3 , 56. The second segment would give the distance between point 2 and 3 and the velocity at point 3, and so on. Any profile can be programmed using MDV moves.



From the following table, write a program to execute the move profile shown, and run it.

Segment Number	Distance moved during segment	Velocity at the end of segment
1	3	56
2	3	12
3	4	16
4	2	57
5	2.5	57
6	3	11
7	5	20
8	5	0
-	-	-

```
;Segment moves
MDV   3 , 56
MDV   3 , 12
MDV   4 , 16
MDV   2 , 57
MDV   2.5 , 57
MDV   3 , 11
MDV   5 , 20
MDV   5 , 0
END
```

The following equation can be used to calculate the acceleration that results from segment move.

Accel = (V2f - V20) / 2*D

Vf - Final velocity
V0 - Starting velocity
D - Distance

S-curve Acceleration

Instead of using linear acceleration, motion created using segment moves (MDV statements) can use S-curve acceleration. The syntax for MDV move with S-curve acceleration is:

MDV <distance>,<velocity>,S

Segment using S-curve acceleration will take the same amount of time as linear acceleration segment. S-curve acceleration is useful because it is mach smoother at the beginning and end of the segment, however, the peak acceleration of the segment will twice as high as the acceleration used in the linear acceleration segment.

Motion SUSPEND/RESUME.

There is a need sometimes to delay motion by filling motion stack with motion profiles ahead of time and then execute motion in some predetermined instance. Statement MOTION SUSPEND will suspend motion until statement MOTION RESUME is executed. When motion is suspended any execution of the motion statement will place motion segment (profile) to the motion stack. When MOTION RESUME is executed motion will be started with the first placed segment in motion stack. Here is the example:

```
                MOTION SUSPEND
                MDV   10,2          ;placed in stack
                MDV   20,2          ;placed in stack
                MDV   2,0           ;placed in stack
MOVED 3, C      ;must use ",C "modifier. Otherwise dead lock ;will result.

MOTION RESUME
```

Caution should be taken when using MOVED,MOVEP and MOVE statements. If any of the MOVE instructions without ",C" modifier is executed dead lock will result because it will be placed in the stack and program will be suspended until it is executed. In the turn execution will not happened until enabled so program will be waiting infinitely.

Conditional moves (MOVE WHILE/UNTIL)

Statement MOVE UNTIL <expression> or MOVE WHILE <expression> will start motion with set acceleration and velocity and continues until <expression> became TRUE for MOVE UNTIL or while <expression> is true for MOVE WHILE. Expression can be any valid arithmetic or logical expressions or their combination. Here is some examples:

MOVE WHILE APOS<20 ;Move before position becomes less then 20 , then ;stop with current deceleration rate.

MOVE UNTIL APOS<V1

;Move positive until position less the position value contained in user variable V1

MOVE BACK UNTIL APOS<V1

;Same as above but direction of move changed. (Going negative)

MOVE WHILE IN_A1 ;Move positive while input 0 is activated.

MOVE WHILE !IN_A1 ;Move positive while input 0 is not activated. The exclamation mark (!) in front of IN_A1 inverts (or negates) value of IN_A1.

Last example is a convenient way to find a sensor or switch.

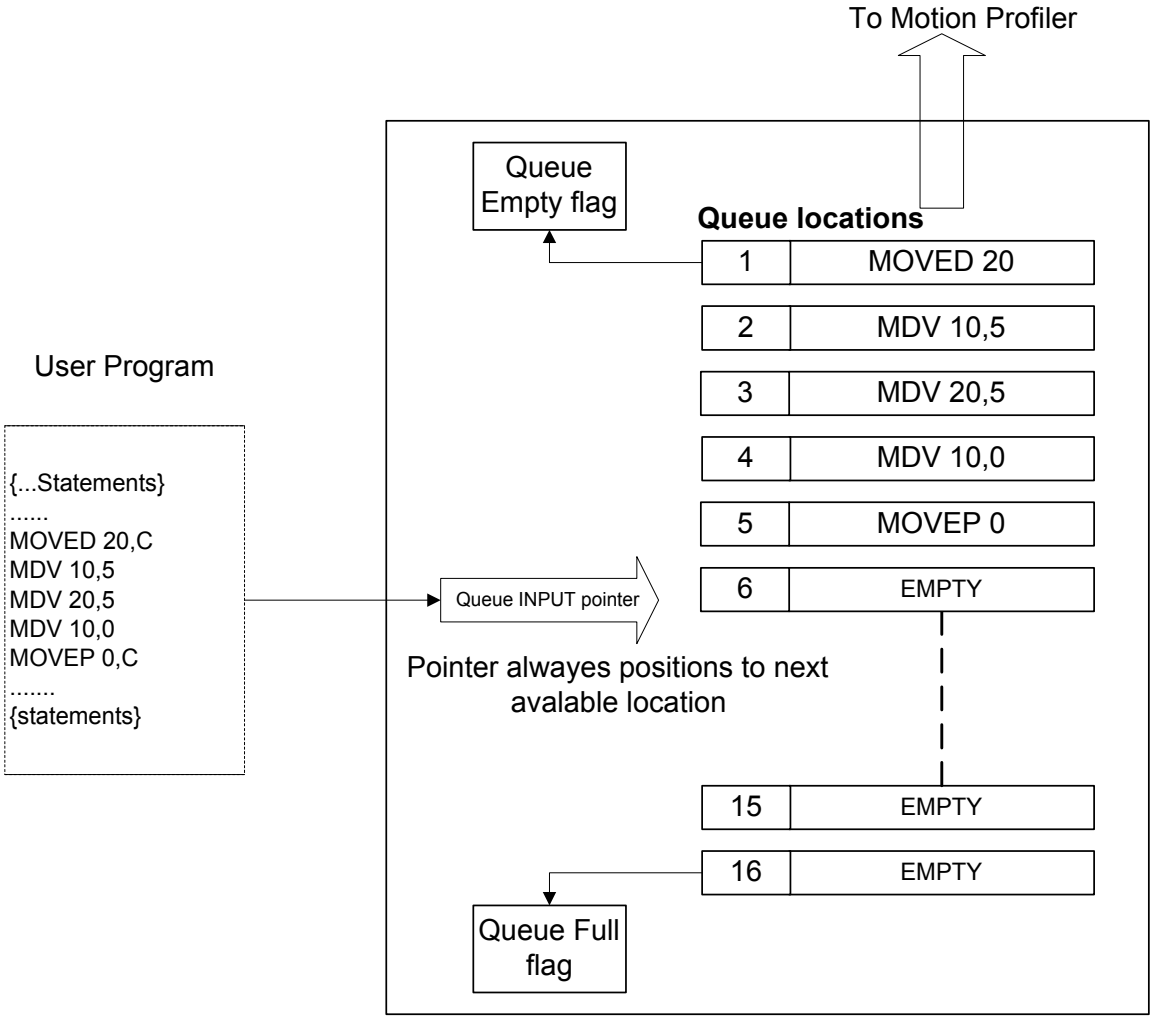
Motion Queue and statements execution while in motion

By default when program executes MOVE, MOVED or MOVEP statements it waits until motion complete before to go to the next statement. This effectively will suspend the program until requested motion is done. Note those events are not suspended however and keep on executing in parallel. While this is convenient for simple motion program it could be a troublesome when trying to do monitoring and controlling I/O at the same time when execute motion. Consider a short program:

```
;This program monitors I/O in parallel with motion:
START:
      MOVED 100,C             ;start moving max 100 revs
WHILE  FLAG_MOTION            ;while moving
      IF IN_A2 == 1           ;if sensor detected
            OUT1=1            ;turn ON output for
            WAIT TIME 10            ;10 mS
            OUT1=0            ;turn output OFF
      ENDIF
ENDWHILE
;Return mechanism back
      MOVED -100              ;Return back
      WAIT TIME 1000          ;wait time
      GOTO START              ;and start all over
      END
```

This program starts motion and moves for maximum 100 revs. While in motion if it sees sensor (or switch) it turns output for 10mS. The programs able to look for the sensor while executing motion because of ",C" modifier for MOVED statement. Without this modifier program would be suspended until all motion is done making impossible to look for the sensor on input #1. After it travels the full distance it returns back to initial position and process repeats. This program could be used for simple paint mechanism which turns ON paint spray as soon as part edge (or part guide) crosses the sensor(s).

On the other hands MDV statement execution never suspends the program because each individual statement sets portions of motion profile. Every motion profile or portion of (in case of MDV statement) generated by motion statements MOVEP,MOVED or MDV first go to Motion Queue and than executed one by one. In the other hand if statement doesn't have ",C" modifier motion profile generated by this statement goes to Motion Queue and program suspended until this profile has been executed. Diagram below shows structure and operation of Motion Queue.



Motion Queue is 32 entries deep. System Status Register's flag #7 indicates state of Motion Queue. Flag is set if there is no more empty space in the Queue. Programmer should check this flag before executing any MOVE statements if the possibility of overflow exists especially in programs where MOVE statements executed in lopped fashion. Attempt to execute motion statement while Motion Queue full will result in fault #23. MDV statements don't have "C" option. Program is never suspended by MDV statements. If last MDV statement in the Queue is statement specifies non 0 velocity Motion Stack Underflow fault #24 will occur.

It is essential for program to execute final MDV statement before last motion statement is completed. It is especially true for very short MDV moves. Since motion starts immediately after first motion statement, in

case when MDV moves are very short (take very short time to execute) use MOTION SUSPEND statement first to execute several MDV statements (witch effectively will fill Queue) and that execute MOTION RESUME to start motion.

2.14 System Status Register (DSTATUS register)

System Status Register is Read Only register. It's bits indicate various states of SSi subsystems. Some of the flags are available as System Flag variables and summarized in table

Bit in register	Description
0	Set when drive enabled
1	Set if DSP subsystem at any fault
2	Set if drive has a valid program
3	Set if byte-code or system or DSP at any fault
4	Set if drive has a valid source code
5	Set if motion completed and target position is within specified limits
6	Set when scope is triggered and data collected
7	Set if motion stack is full
8	Set if motion stack is empty
9	Set if byte-code halted
10	Set if byte-code is running
11	Set if byte-code is set to run in step mode
12	Set if byte-code is reached the end of program
13	Set if current limit is reached
14	Set if byte-code at fault
15	Set if no valid motor selected
16	Set if byte-code at arithmetic fault
17	Set if byte-code at user fault
18	Set if DSP initialization completed
19	Set if registration has been triggered
20	Set if registration variable was updated from DSP after last trigger
21	Set if motion module at fault
22	Set if motion suspended
23	Set if program requested to suspend motion
24	Set if system waits completion of motion
25	Set if motion command completed and motion Queue is empty
26	Set if byte-code task requested reset
27	If set interface control is disabled. This flag is set/clear by ICONTROL ON/OFF statement.
28	Set if positive limit switch reached
29	Set if negative limit switch reached
30	Events disabled. All events disabled when this flag is set. After executing EVENTS ON all events previously enabled by EVENT Event*Name* ON statements become enabled again

2.15 Fault Codes (DFAULTS register)

Whenever fault has occurred it will be recorded in special system variable called Fault Register. In addition specific flags in System Status Register (see next section for details) will be set helping to indicate what class of faults occurred fault belongs to. Below is the table summarizing possible fault codes. Codes from 1 to 16 are reserved for DSP subsystem errors. Codes above that range are generated by various systems of SSi.

Fault ID	Associated flags in status register	Description
1	1, 3	Overvoltage
2	1, 3	Invalid hall sensors code
3	1, 3	Overcurrent
4	1, 3	Overtemperature
5	1, 3	Reserved
6	1, 3	Overspeed. (Overspeed limit set by motor capability in motor file)
7	1, 3	Position error excess.
8	1, 3	Attempt to enable while motor data array invalid or motor was not selected.
9-16		Reserved
17	3	Unrecoverable error.
18	16	Division by zero
19	16	Arithmetic overflow
20	3	Subroutine stack overflow. Exceeded 16 levels subroutines stack depth.
21	3	Subroutine stack underflow. Attempt to execute RETURN statement without preceding call to subroutine.
22	3	Variable evaluation stack overflow. Expression too complicated for compiler to process.
23	21	Motion Queue overflow. 32 levels depth exceeded
24	21	Motion Queue underflow. Last queued MDV statement has non 0 target velocity
25	3	Unknown opcode. Byte code interpreter error
26	3	Unknown byte code. Byte code interpreter error
27	21	Drive disabled. Attempt to execute motion while drive is disabled.
28	16, 21	Accel too big. Motion statement parameters result in calculating too big Accel value for system to handle
29	16, 21	Accel too small. Motion statement parameters result in calculating too small Accel value for system to handle
30	16, 21	Velocity too big. Motion statement parameters result in calculating too big velocity value for system to handle
31	16, 21	Velocity too small. Motion statement parameters result in calculating too small velocity value for system to handle

2.16 Limitations and restrictions

Communication Interfaces usage restrictions

Simultaneous connection to RS232 and RS485 is allowed for the purpose of retransmitting (conversion) between interfaces.

Usage of either RS232 or RS485 simultaneously with Ethernet may lead to unpredictable behavior since drive will attempt to perform commands from both interfaces concurrently.

Motion parameters limitation

Due to finite precision in the calculations there are some restrictions for acceleration/deceleration and max velocity for the move. If you receive arithmetic faults during your program execution it is likely due to these limitations. Min/Max values are expressed in counts or counts/sample, where sample - position loop sample interval and equal 256uS.

Parameter	MIN	MAX	Units
Accel / Decel	65/(2^32)	512	counts/sample^2
MaxV (maximum velocity)	0	2048	counts/sample
Max move distance	0	+/- 2^31	counts

Stacks and queues depth limitations

Motion Queue	32
Subroutines Stack	32
Number of events	32

3. Language Reference

Format

Each statement, system variable or operand is documented using the format shown below. If there is no information in one of the fields the label is still shown.

KEYWORD	Long Name	Type

Purpose

Syntax KEYWORD=value
Variable=KEYWORD
Arguments

Remarks

See Also

Example

KEYWORD: The KEYWORD is the name of the statement, system variable or system flag as it would appear in a program.

Long Name: The long name is an interpretation of the keyword. For example: MOVEP Is the keyword and Move to Position would be a long name. The long name is provided only as an aid to the reader and may not be used in a program.

Type: This field identifies what type of statement or system variable the keyword is.

Purpose: purpose of the keyword.

Syntax: This field shows proper usage of the keyword**.** Optional arguments will be contained within squire brackets [ ]. Arguments will be written in italics.

Arguments: The data that is supplied with a statement that modifies the behavior of the statement. For example, MOVED=100. MOVED is the statement and 100 is the argument.

Remarks: The remark field contains additional information about the usage of the statement or system variable.

See Also: This field contains a list of statements or system variables that are related to the purpose of the keyword.

Example: The example field contains a code segment that illustrates the usage of the keyword

Reference

ASSIGN	Assign Input As Index Bit	Statement

Purpose Assign keyword causes specific input act as particular bit of system variable INDEX . After such assignments changes in input state will cause changes in particular bit input is assign to.

Syntax ASSIGN IINPUT <input name> AS BIT <bit #>

Input name input name (IN_A1..IN_A2 etc.)
Bit# INDEX variable bit number from 0 to 31

Remarks

See Also

Example: ASSIGN INPUT 5 AS BIT 0 ;index bit 0 state ;matches ;state of input 5

DEFINE	Define name	Pseudo-statement

Purpose DEFINE is used to define symbolic names for variables and constants for programming convenience. It is a pseudo-statement i.e. it is not executable. DEFINE can be used also to substitute symbolic string.

Syntax

DEFINE <name> <string>

name any symbolic string
string any symbolic string

Remarks: DEFINE must be located before any executable statement

See Also

Example:

```
DEFINE  Five      5 DEFINE  Three    3DEFINE  Result  V1
DEFINE  SUMM Five + Three

ProgramStart:
     Result = Five + Three          ;Is same as V1 = 5+3
     Result = SUMM                  ;same result as above
     End
```

DISABLE	Turns servo OFF	Statement

Purpose DISABLE turns power to the motor OFF and disables servo.

Syntax DISABLE

Remarks After execution of enable APOS and TPOS not valid. They will remain their last values before DISABLE has been invoked. They will be reset to 0 after execution of ENABLE statement.

See Also ENABLE

Example: DISABLE

DO UNTIL	Do/Until	Statement

Purpose DO <statement(s)> UNTIL <condition> executes the statement(s) between DO and UNTIL repeatedly until <condition> specified becomes TRUE.

Syntax DO <statement(s)> UNTIL <condition>

<statement(s)> any valid statement(s)
<condition> The condition to be tested.

The condition may be a comparison, an input being TRUE or FALSE (H or L) system flag or a variable used as flag (if 0 - false, else - true). Comparisons compare the values of two operands and determine if the condition is TRUE or FALSE. A comparison may be greater (>), less than (<), less than or equal (<=), or greater than or equal to (>=). The operands of a comparison may be user variable, system variables, analog input values, or constants.

```
IN_A1          ;an input is evaluated to true if active
V1             ;user variable. True when non 0, false
;when 0
INPOSITION     ;system flag
V1 > V2        ;user variable comparison
V1 > APOS      ;comparison user and system variables
APOS < 8.4     ;compare system variable to constant
```

Remarks Unlike WHILE statement, the loop body will always be executed at least once because the DO/UNTIL statement tests the <condition> AFTER the loop body is executed.

See Also WHILE, IF

Example:

```
DO MOVED V1
 WAIT TIME  2000   ;Do statements while
     WHILE IN_A2           ;IN_A2 is activated (TRUE)
```

ENABLE	Enables servo	Statement

Purpose Turns power to the motor on and enables the servo

Syntax ENABLE

Remarks After ENABLE is executed APOS and TPOS variables reset to 0

See Also DISABLE

Example: ENABLE ;servo turns on after this statement

END	END program	Statement

Purpose This statement is used to terminate (finish) user program and its events.

Syntax END

Remarks END can be used anywhere in program

See Also DISABLE

Example: ENABLE ;servo turns on after this statement

EVENT	Starts Event handler	Statement

Purpose Event keyword creates scanned event handler. Statement also sets one of 4 types of events possible.

Syntax

1. EVENT <name> INPUT <inputname> RISE
   Or
2. EVENT <name> INPUT <inputname> FALL
   Or
3. EVENT <name> TIME <period >
   Or
4. EVENT <name> <expression>

name	any valid alphanumeric string
number	any integer number
period	any integer number. Expressed in ms
expression	any arithmetic or logical expression

Following statements can't be used within event's handler:

MOVE,MOVED,MOVEP,MOVEDR,MOVEPR,MDV,
MOTION SUSPEND
MOTION RESUME
STOP MOTION
DO UNTIL
GOTO
GOSUB
GEAR ON/OFF
HALT
VELOCITY ON/OFF
WAIT
WHILE

While GOTO or GOSUB are restricted, a special JUMP statement can be used for program flow change from within event handler. See JUMP statement description in Language Reference section.

Remarks:

For syntax 1 and 2:
Event occurs when input with <name/number> transition from L to H occurs for syntax 1 and from H to L occurs for syntax 2.

For syntax 3:
Event occurs when specified in <period> period of time has expired. This event can be used as periodic event to check for some conditions.

For syntax 4
Event occurs when expression in <expression> evaluates to true. Expression can be any valid arithmetic or logical expression or combination of two. This event can be used when implementing soft limit switches or change program flow based on some conditions. Any variable (user and system) and constants can be used in expression.

See Also: ENDEVENT, EVENT ON, EVENT OFF

Example:

```
        V0=0
        V1=0
EVENT InEvent INPUT  1 RISE
                V0 = V0+1                ;count
        ENDEVENT
;
        EVENT period  TIME     1000     ;1000 ms = 1Sec
V3=V0-V1                        ;new count - old count = number of pulses per
;second
        V0=V1                           ;save as old count
;-------------------------------------------------------------------------------------------------------------------
        EVENT  InEvent  ON
        EVENT period     ON

        {program statements}

END
```

ENDEVENT End of Event handler Statement

Purpose Indicates end of the event handler

Syntax ENDEVENT

Remarks

See Also EVENT, EVENT ON, EVENT OFF

Example:

```
        EVENT   InputRise INPUT RISE
                V0=V+1
        ENDEVENT
```

EVENT ON/OFF **Turn events on or off** **Statement**

Purpose turns events created by EVENT handler statement ON or OFF

Syntax EVENT <name> ON
EVENT <name> OFF

<name> Event handler name

Remarks

See Also EVENT

Example:

EVENT InputRise ON
EVENT InputRise OFF

EVENTS ON/OFF **Globally Enables/disables events** *Statement*

Purpose Enables/Disables events execution previously enabled by EVENT Eventname ON statement. This is global ON/OF control. Effects flag #30 in DSTATUS register - F_EVENTSOFF. After executing EVENTS ON individual event's on/off states restored.

Syntax

EVENTS ON	Restores execution of enabled events
EVENTS OFF	Disables all execution of all events

Remarks Events are globally enabled after reset and controlled by individual Event Eventname ON statements.

See Also EVENT ON/OFF

Example:

```
EVENT Event1 IN_A1 RAISE  ; switch event
      JUMP EventCodeProcess
ENDEVENT

EVENT Event2 IN_A1 RAISE  ; switch event
      JUMP EventCodeProcess
ENDEVENT

EVENT Event1 ON
EVENT Event2 ON
{
      User code
}

EVENTS OFF              ;all events are disabled

.
.
EVENTS ON               ;Events Event1 and Event2 enabled again
```

FAULT	**User generate fault**	*Statement*

Purpose Allows user program set custom system fault. This is useful when custom program needs to standard fault process for custom conditions like data supplied by interface out of range etc. Custom fault numbers must be in region of 128 to 240 (decimal)

Syntax FAULT *FaultNumber* Sets system fault.

Faultnumber – constant in range 128-240

Variables are not allowed in this statement.

Remarks Custom fault will be processed as any regular fault. There will be a record in the fault log.

See Also ON FAULT

Example:

```
FAULT 200          ;Sets fault #200

V0=200
FAULT V0           ;incorrect. Variables not allowed here
```

GEAR ON/OFF	Gearing Mode	Statement

Purpose GEAR ON enables gearing mode. Gear OFF disables gearing mode and returns SSi to default mode. (Default mode is Indexing). Gearing ration is established by setting System Variable GRATIO. Master encoder resolution (PPR) is set by System Variable MEPPR. Default setting for GRATIO as 1 and MEPPR is set to motor encoder PPR.

Syntax GEAR ON
GEAR OFF

Remarks GEAR ON statement considered one of the motion related commands. It has to be used when drive enabled. If GEAR ON statement is met when drive is disabled fault # 27-"Drive disabled".

Execution of any motion related statement while in Gearing mode cause SSi to put motion command to Motion Queue. After execution of GEAR OFF statements SSi returns to default Indexing mode and start execute motion commands from Queue immediately. Note that GRATIO can be set on the fly which allows dynamic control of the gearing ratio.

See Also VELOCITY ON, VELOCITY OFF

Example:

```
GRATIO 2    ;set initial ratio 2:1. 2 motor revs per ;1 master rev
            GEAR ON
            …{statements}
            GRATIO =AIN   ;set ration dependant on Analog input ;value
            …{statements}
            GEAR OFF
```

GOTO	Go To	Statement

Purpose Transfer program execution to the instruction following the label.

Syntax GOTO <label>

Remarks

See Also GOSUB, JUMP

Example:

```
            GOTO Label2
            {Statements…}

Label2: {Statements…}
```

GOSUB	**Go to subroutine**	**Statement**

Purpose GOSUB transfers control to <subname> subroutine.

Syntax GOSUB <subname>

<subname> a valid subroutine name

Remarks After return from subroutine program resumes from next statement after GOSUB

See Also GOTO, JUMP, RETURN

Example:

```
        DO
GOSUB  CALCMOVE
                MOVED          V1
        WHILE  1
        END

SUB     CALCMOVE
                V1=(V2+V3)/2
        RETURN
```

HALT	**Halt the program execution**	*Statement*

Purpose Used to halt main program execution. Events are not halted by HALT statement. Execution will be resumed by RESET statement or by executing JUMP to code from EVENT handler.

Syntax

```
HALT
```

Remarks This statement is convenient when writing event driven programs.

See Also RESET

Example:

```
{Statements…}
HALT
```

JUMP Jump to label from Event handler Statement

Purpose This is special purpose statement to be used only in event's handler code. If this statement is met in Event's handler code user's program will resume its operation from location pointed by <label> argument of Jump statement after event handler code finishes. This statement is particularly useful when there is a need for program's flow change based on some event(s).

Syntax JUMP <label>

<label> any valid program label

Remarks Can be used in EVENT handler only.

See Also EVENT

Example:

```
{Statements…}
                EVENT ExternalFault INPUT IN_A3 FALL
JUMP ExecuteStop ;start execute program from ;label <ExeceuteStop> at the ;end of this event
                ENDEVENT
                {statements}
StartMotion:
                EVENT ExternalFault ON
                ENABLE
MOVED 20
                MOVED       -100

                {statements}


                END

ExecuteStop:
                STOP MOTION                     ;Motion stopped here
                DISABLE                         ;drive disabled
                CALL WaitExternalFaultClear     ;wait untill external fault
                                                ;is clear
                GOTO StartMotion
```

ICONTROL ON/OFF Enables interface control *Statement*

Purpose Enables/Disables interface control. Effects flag #27 in DSTATUS register F_ICONTROLOFF.

in DSTATUS register. All interface motion commands and commands changing any outputs will be disabled. See Host interface commands manual for details. This command is useful when program processing critical states (like limit switches for example) and can't be disturbed by interface (usually asynchronous body to the program state/event)

Syntax ICONTROL ON Enables Interface control

ICONTROL OFF Disables interface control

Remarks After reset interface control is enabled by default.

See Also

Example:

```
EVENT LimitSwitch IN_A1 RAISE  ; limit switch event

      Jump LimitSwitchHandler  ; jump to process limit switch

ENDEVENT
V0=0
EVENT LimitSwitch ON

Again:

HALT                    ;system controlled by interface

LimitSwitchHandler:

EVENTS OFF              ;turn off all events
ICONTROL OFF            ;disable interface control
STOP MOTION QUICK       ;
DISABLE                 ;optional DISABLE
V0=1                    ;indicate fault condition to the interface
ICONTROL ON
EVENTS ON
GOTO AGAIN
```

IF — If/Then/Else — Statement

Purpose The IF statement tests for a condition and then executes the specific action(s) between IF and ENDIF statements if condition is satisfied. If condition is false, no action is taken and the instruction following ENDIF statement is executed. Optionally, a second action(s) may be specified to be executed if the condition is false.

Syntax

IF <condition>
{statements 1}
[
ELSE
{statements 2}
]
ENDIF

<condition> The condition to be tested. The condition may be a comparison, an input being TRUE or FALSE (H or L) system flag or a variable used as flag (if 0 - false, else - true).

Comparisons compare the values of two operands and determine if the condition is TRUE or FALSE. A comparison may be greater (>), less than (<), less than or equal (<=), or greater than or equal to (>=). The

operands of a comparison may be user variable, system variables, analog input values, or constants.

```
                IN_A1           ;an input is evaluated to true if active
                V1              ;user variable. True when non 0, false
;when 0
                INPOSITION      ;system flag
                V1 > V2         ;user variable comparison
                V1 > APOS       ;comparison user and system variables
                APOS < 8.4      ;compare system variable to constant
```

{Statements1} statements will be performed if condition is TRUE
{Statements 2} statements will be performed if condition is FALSE

Remarks Only {Statements 1} or {Statements 2} will be performed. It is impossible for both to take place.

See Also WHILE, DO

Example:

```
        IF APOS  > 4
                V0=2
;-------------------------------------------------------
        ELSE
V0=0
        ENDIF
;-------------------------------------------------------
        If V1 <> V2 && V3>V4
                V2=9
        ENDIF
```

MOVE — Move — Statement

Purpose MOVE UNTIL performs motion until condition becomes TRUE. MOVE WHILE performs motion while conditions stays TRUE. Statement suspends the program execution until motion is completed unless statement is used with C modifier.

Syntax

```
MOVE [BACK]  UNTIL <condition>  [,C]
MOVE [BACK]  WHILE <condition> [,C]
```

BACK Optional. Changes direction of the move.

C Optional.

C[ontinue] modifier allows program to continue while motion is performed. If the other motion is not completed yet requested motion is placed in motion stack. Motion stack is 32 entries deep. If there is no

more stack space fault will result. Programmer should check F_MQUEUE_FULL system flag to see if there is available space.

<condition> The condition to be tested. The condition may be a comparison, an input being TRUE or FALSE (H or L) system flag or a variable is used as flag (if 0 - false, else - true).

Remarks

See Also MOVEP, MOVED, MOVEPR, MOVEDR, MDV, MOTION SUSPEND, MOTION RESUME

Example:

```
{Statements…}

MOVE UNTIL V0<3
MOVE BACK UNTIL V0>4
MOVE WHILE V0<3
MOVE BACK WHILE V0>4

MOVE WHILE V0<3,C
```

MOVED Move Distance Statement

Purpose MOVED performs incremental motion (distance) specified in User Units. Valid range for distance is -231 to 231. Statement suspends the program execution until motion is completed unless statement is used with C modifier. If "S" modifier is used S-curve accel is performed during the move.

Syntax MOVED <distance>[,S] [,C]

C[ontinue] optional modifier allows program to continue while motion is performed. If the other motion is not completed yet requested motion is placed in motion stack. Motion stack is16 entries deep. If there is no more stack space fault will result. Programmer should check F_MQUEUE_FULL system flag to see if there is available space.

S[-curve] optional modifier specifies S-curve acceleration.

See Also MOVE, MOVEP, MOVEPR, MOVEDR, MDV, MOTION SUSPEND, MOTION RESUME

Example:

```
{Statements…}

MOVED 3              ;moves 3 user units forward
MOVED BACK 3         ;moves 3 user units backward

{Statements…}
```

MOVEP	Move to Position	Statement

Purpose MOVEP performs motion to specified absolute position in User Units. Valid range for Absolute position from -231 to 231 Statement suspends the program execution until motion is completed unless statement is used with C modifier. If "S" modifier is used S-curve accel is performed during the move. After enabling indexer (by execution of statement or Host Interface command) absolute position is reset to zero. Current Absolute position can be set at any time by setting System Variable APOS to any valid numeric value. APOS=300 makes current position to be 300 User Units.

Syntax MOVEP <absolute position>[,S] [,C]

C[ontinue]	optional modifier allows program to continue while motion is performed. If the other motion is not completed yet requested motion is placed in motion stack. Motion stack is 16 entries deep. If there is no more stack space fault will result. Programmer should check F_MQUEUE_FULL system flag to see if there is available space.
S[-curve]	optional modifier specifies S-curve acceleration.

See Also MOVE, MOVED, MOVEPR, MOVEDR, MDV, MOTION SUSPEND, MOTION RESUME

Example:

```
{Statements…}

MOVEP 3              ;moves to 3 user units absolute position

{Statements…}
```

MOVEDR	Registered Distance Move	Statement

Purpose MOVEDR performs incremental motion (distance) specified in User Units. If during motion registration input has been activated then current position is recorded. Displacement (second statement argument) is added to recorded position to form new target position. The end of the move is then altered to new target position. Statement suspends the program execution until motion is completed unless statement is used with C modifier.

Syntax MOVEDR <distance>,<displacement> [,C]

C[ontinue]	optional modifier allows program to continue while motion is performed. If the other motion is not completed yet requested motion is placed in motion stack. Motion stack is 16 entries deep. If there is no more stack space a fault will result. Programmer should check F_MQUEUE_FULL system flag to see if there is available space.

See Also MOVE, MOVEP, MOVEPR, MOVED, MDV, MOTION SUSPEND, MOTION RESUME

Example:

```
                {Statements…}

                                        MOVEDR  3, 2  ;moves incrementally 3 user units
                                                      ;if registration was not detected.
        ;if registration was detected add ;displacement
        ;of 2 user units to registration position
        ;and alter the end  position of the move

                                        {Statements…}
```

MOVEPR	**Registered Position Move**	**Statement**

Purpose — MOVEPR performs absolute position move specified in User Units. If during motion registration input has been activated then current position is recorded. Displacement (second statement argument) is added to recorded position to form new target position. The end of the move is then altered to new target position. Statement suspends the program execution until motion is completed unless statement is used with C modifier.

Syntax — MOVEPR <distance>,<displacement> [,C]

C[ontinue] — optional modifier allows program to continue while motion is performed. If the other motion is not completed yet requested motion is placed in motion stack. Motion stack is16 entries deep. If there is no more stack space fault will result. Programmer should check F_MQUEUE_FULL system flag to see if there is available space.

See Also — MOVE, MOVEP, MOVEDR, MOVED, MDV, MOTION SUSPEND, MOTION RESUME

Example:

```
                {Statements…}

MOVEPR  3, 2    ;moves to absolute position of  3 user ;units
                                        ;if registration was not detected.
                                        ;if registration was detected add
;displacement
;of 2 user units to registration position
;and alter the end  position of the move

                {Statements…}
```

MDV **Segment Move** **Statement**

Purpose MDV defines incremental motion segment by specifying distance and final velocity (for this segment) in User Units. Acceleration (or deceleration) is calculated automatically based on this two parameters. This technique allows to create complicated moves consist of many segments. To execute any move you must specify at least two segments because at the end of the move final velocity has to be 0. That's why any complicated move consisting of many MDV statements must end with statement has final velocity argument set to 0. MDV statement doesn't suspend main program execution. They placed in Motion Queue immediately. If SSi fetches last segment from Motion Queue with its final velocity non 0 it will generate "Motion Queue Empty" fault #24. If "S" modifier is used in statement than velocity acceleration/deceleration will be S-curved as opposed to be linear.

Syntax MDV <[-]segment distance>,<segment final velocity> [,S]

S[-curve] optional modifier specifies S-curve acceleration.

See Also MOVE, MOVEP, MOVEDR, MOVED, MOVEPR ,MOTION SUSPEND, MOTION RESUME

Example:

```
{Statements…}

MDV  5, 10      ;accelerate to velocity of 10
MDV  10,10      ;move 10 user units with velocity of 10
MDV 10,5        ;decelerate to velocity of 5
MDV  5,0        ;decelerate to velocity 0. (last MDV has to
                ;have 0 final velocity)

{Statements…}
```

MOTION SUSPEND **Suspend** **Statement**

Purpose This statement is used to temporarily suspend motion without flashing Motion Queue content. Motion will be suspended after completion of current move. If Motion Suspend is executed while executing series of MDV statements motion will be suspended only after MDV segment with zero final velocity. If command is executed while Motion Queue empty any motion related statement will be placed in Motion Queue but not executed until Motion Resume statement allows motion. Any motion statements without "C" modifier (except MDV statements which never suspend program) will dead-lock user program. Consider following program:

```
;Program dead-locks after MOVE statement executed
                …{statements}
                MOTION SUSPEND          ;everything placed in Queue
                                        ;after this statement
MOVE 20         ;placed in Queue and suspend
;program until completed
                …{statements}

MOTION RESUME   ;never gets here because
```

;program is suspended so motion ;will never ;starts

You can unlock this situation only by reset or execution MOTION RESUME command from Host Interface.

Syntax MOTION SUSPEND

Remarks Performing any MOVEx commands without "C" modifier will dead-lock user program. You will be able to unlock it only by performing Reset or Host Interface command "Motion Resume"

See Also MOVE, MOVEP, MOVEDR, MOVED, MOVEPR ,MDV, MOTION RESUME

Example:

…{statements}

MOTION SUSPEND ;motion will be suspended after current motion ;command finishes

…{statements}

MOTION RESUME Resume Statement

Purpose Statement resumes motion previously suspended by MOTION SUSPEND. If motion was not previously suspended, this has no effect on operation.

Syntax MOTION RESUME

See Also MOVE, MOVEP, MOVEDR, MOVED, MOVEPR ,MDV, MOTION SUSPEND

Example:

…{statements}

MOTION RESUME;motion is resumed from current command in
;motion Queue (if any)

…{statements}

ON FAULT/ENDFAULT On Fault Statement

Purpose Statement starts fault handler section. Fault handler is a piece of code which called upon any fault occurrence. Fault handler starts with ON FAULT statement and must be ended with ENDFAULT statement. If fault handler is not defined any fault will cause user program termination. When SSi goes to fault state it will disable drive and enter fault handler. All scanned events will be disabled until program in fault handler. Fault handler needs to be ended with RESUME or RESET statements. If program reaches statement ENDFAULT before RESUME or RESET statements user program will terminate (come to the end). Certain statements can't be used in fault handler.

Following statements can't be used in fault handler:

MOVE,MOVED,MOVEP,MOVEDR,MOVEPR,MDV,
MOTION SUSPEND
MOTION RESUME
GOTO
GOSUB
JUMP
ENABLE
GEAR ON/OFF
VELOCITY ON/OFF

Syntax ON FAULT

{…statements}

ENDFAULT

See Also RESUME, RESET

Example:

…{statements}
FaultRecovery:
…{statements}

END

```
ON FAULT                    ;any fault gets program flow here

                …{statements}

RESUME FaultRecovery        ;execution of resume ends fault handler
                                ;if resume is omitted program will terminate
ENDFAULT                    ;must end with this terminator
```

REGISTRATION ON — Registration On — Statement

Purpose This statement arms registration input (input IN_C3). When registration input is activated current position is captured to the RPOS System variable and Flag variable F_REGISTRATION is set. User program then can retrieve RPOS to get a position when registration input was activated. REGISTARTION ON statement resets F_REGISTARTION flag.

Syntax

```
                    REGISTARTION ON     ;flag F_REGISTARTION is reset and
                    registration input is
                    ;armed
```

See Also MOVEDR, MOVEPR

Example:

```
            …{statements}
;Move until input is activated and then come back at the sensor ;position

REGISTARTION ON     ;Arm registration input
MOVE UNTIL IN_C3  ;move until input is activated -
;sensor hit
MOVEP       RPOS        ;absolute move to the position of
;the sensor

            …{statements}
```

RESUME — Resume — Statement

Purpose End and return from a fault handler to a specific line as specified by <label> argument. Statement aloowed only in fault handler

Syntax RESUME <label>

<label> specifiec program's line marked with <label>

See Also ON FAULT

Example:

```
            …{statements}
FaultRecovery:
            …{statements}

            END

ON FAULT                ;any fault gets program flow here

            …{statements}

RESUME FaultRecovery    ;execution of resume ends fault handler
ENDFAULT                ;must end with this terminator
```

RETURN — Return from subroutine — Statement

Purpose Return from a subroutine to the point in the program from where the subroutine was called. If statement was executed without previous call to subroutine, fault #21 "Subroutine stack underflow" will result.

Syntax RETURN

See Also GOTO, GOSUB

Example:

```
…{statements}…
GOSUB MySub      ;motion is resumed from current command in
;motion Queue (if any)
                 MOVED 10
…{statements}
END                              ;main program end

MySub:
                          …{statements}
                 RETURN          ;returns to MOVED 10 statement
```

SEND/SENDTO — Send network variable(s) value — Statement

Purpose Statements make an effect only on the drives in Ethernet network. When this SEND statement executes value(s) of network variable(s) N0..N31 listed in statement broadcasted throughout entire network and gets synchronized (set to the same value as broadcasted) on every drive in network. SENDTO statement makes effect on network variables of the drives with the same group ID listed in command.

Syntax SEND [Na,Nb, Nx-Ny], SENDTO Grouped [Na,Nb, Nx-Ny]

a,b,x,y	any number from 0 to 31
GroupID	GroupID of the drives who's variables will be affected (synchronized)

See Also Network variables

Example:

```
…{statements}…
N1=12            ;N1 local copy get the value
SEND [N1]        ;every drive's N1 in network
                 ;gets to set to 12
;
SEND [N5-N10]    ;Variables from N5 trough N10 on every drive in ;network get set to the same value
N20=25
SENDTO 2 [N20]   ;Only drives with GroupID = 2 effected.

…{statements}
END                      ;main program end
```

STOP MOTION [QUICK] Stop Motion Statement

Purpose Stop (abort) motion immediately with deceleration rate set by DECEL System Variable or QDECEL Variable if QUICK modifier is used and flash contest of the Motion Queue. Main usage for controlled emergency stop or when End Of Travel sensor is detected. Current position will be not lost after execution of this statement.

Syntax

```
STOP MOTION              ;stops using DECEL deceleration rate
STOP MOTION QUICK        ;stops using QDECEL deceleration rate
```

See Also MOTION SUSPEND

Example:

```
…{statements}…

DECEL = 100
QDECEL = 10000

…{statements}

    STOP MOTION QUICK
```

VELOCITY ON/OFF Velocity Mode Statement

Purpose VELOCITY ON enables velocity mode. VELOCITY OFF disables velocity mode and returns SSi to default mode. (Default mode is Indexing). Velocity value for this mode is set by setting System Variable VEL. All position related variables are valid in this mode.

Syntax

```
VELOCITY ON
VELOCITY OFF
```

Remarks VELOCITY ON statement considered one of the motion related commands. It has to be used when drive enabled. If VELOCITY ON statement is met when drive is disabled fault # 27-"Drive disabled".
Execution of any motion related statement while in Velocity mode causes SSi to put motion commands to Motion Queue. After execution of GEAR OFF statements SSi returns to default Indexing mode and start execute motion commands from Queue immediately. Note that VEL variable can be set on the fly, which allows dynamic control of the velocity.

See Also GEAR ON, GEAR OFF

Example:

```
VEL=0                    ;set velocity to 0
VELOCITY ON
VEL = AIN          ;emulating analog voltage control
    …{statements}

    VELOCITY OFF
```

WAIT — Wait — Statement

Purpose Suspend program execution until some condition(s) is met. Conditions include Expressions TRUE or FAULSE, Preset TIME expiration, MOTION COMPLETE.

Syntax

```
WAIT UNTIL <expression>   ;wait until expression becomes     ;TRUE
WAIT WHILE <expression>   ;wait while expression is TRUE
WAIT TIME <time delay>    ;wait until <time delay> in mS is ;expired
WAIT MOTION COMPLETE      ;wait until last  motion in Motion Queue completes
```

Remarks

See Also DSTATUS System Variable, User Variables and Flags section

Example:

```
WAIT UNTIL (APOS>2 && APOS <3)
WAIT WHILE (APOS <2 && APOS>1)
WAIT TIME 1000                ;wait 1 Sec (1 Sec=1000mS)
MDV 20, 20
MDV 20,0
WAIT MOTION COMPLETE          ;waits until motion is done
```

WHILE/ENDWHILE — While — Statement

Purpose The WHILE <expression> executes statement(s) between keywords WHILE and ENDWHILE repeatedly while the expression evaluates to TRUE.

Syntax

```
WHILE <expression>

    {statement(s)}…

ENDWHILE
```

Remarks WHILE block of statements has to end with ENDWHILE keyword.

See Also DO/UNTIL

Example:

```
WHILE          APOS<3        ;execute statements until position
; less than
;preset limit

                                …{statement(s)}..

                             ENDWHILE
```